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Typical Features and Applications of Modern Pushbutton PBX's

By Helmuth Gallo

With their attractively styled gray plastic housings, Siemens telephones combine high technical quality and easy handling with modern design concepts [1]. These features are also reflected in the telephones of Reiha* and Reipos* Pushbutton PBX's [2], where illuminated buttons are used in place of conventional keys and lever switches. The functional arrangement and labeling of these novel illuminated buttons greatly simplifies the handling of the telephone [3]. Pushbutton PBX's offer small businesses all the advantages of modern PBX technology that were hitherto available only to large enterprises.

Reiha Pushbutton PBX's

Reiha Pushbutton PBX's are adapted for one outside trunk and from two to six extensions: Reiha 1/1, 1/2 and 1/5 (Figs. 1, 2, 3). The first digit in the type code denotes the number of outside trunks and the second digit the number of extensions. Each PBX also has a master telephone. Table 1 presents a survey of the available models.

Reiha Pushbutton PBX's find preferred use wherever extensions can be located close together over short lines. The Reiha 1/1 can also be used as an executive-secretary telephone system with a common junction line connected either directly to an outside trunk or to a PABX. Each of the extension telephones has a separate terminal box; there is also a trunk terminal box containing the power supply unit. The outside trunk runs through the trunk terminal box to each extension telephone in turn and finally to the master telephone (Fig. 4). All extension telephones are connected in parallel, share a common inside circuit, and can be called individually over respective ringing circuits by pressing appropriate ringing buttons.

The telephones are extremely easy to handle. All usually have access to the outside trunk, which is obtained by pressing a button. In the case of the Reiha 1/1 each telephone is provided with a visual indicator which shows when the trunk is in use. In the case of the Reiha 1/2 and Reiha 1/5, on the other hand, the busy condition of the trunk is indicated by operation of the red busy lamp in the monitor button of the telephones not in use, while at the telephone in use the pilot lamp (green) burns. Trunk calls can be interrupted as often as desired in order to make consultation calls. Conference calls can be conducted between three or more extensions.

Incoming trunk calls arrive at the master telephone, where they are answered on pressing the trunk button and, if necessary, transferred to a wanted extension by pressing the appropriate ringing button. The extension answers in turn by pressing the trunk button of his own telephone. If desired, certain extensions can be allowed to monitor or participate with full talking privileges in trunk calls in progress at other extensions (monitor button).

Reiha 1/2 and 1/5 PBX's permit an off-premises extension (Fig. 4) to be connected up in place of one inside extension. The first or fifth ringing button of the extension telephones can be circuited for ringing this off-premises extension. The latter is connected to the trunk terminal box, which is installed together with the master telephone, by way of a two-wire lead, the loop resistance of which must not exceed 2×150 ohms. For anything in excess of this value a long-line adapter or supplementary power supply unit should be used.

* Trade-mark

Fig. 1 The telephones of the REIHA 1/1 PBX are provided with a visual indicator, a trunk button *A* (with green lamp), an optimal monitor button *M* (with red lamp), and a ringing button *R*

Fig. 2 Telephone of a REIHA 1/2 PBX. In addition to a trunk button (with green pilot lamp) and a monitor button (with red busy lamp), it has two ringing buttons. The master telephone additionally has a rotary button *N* (for switching one of the two extensions to night service)

One of the extensions or the off-premises extension can be used as a night service extension or ring-transfer extension. The requisite supplementary device may be accommodated in the trunk terminal box and a rotary button for enabling it added to the master telephone. After this night button has been actuated, all incoming trunk calls are routed immediately to the night service extension; otherwise they are not so routed until about 30 sec have elapsed.

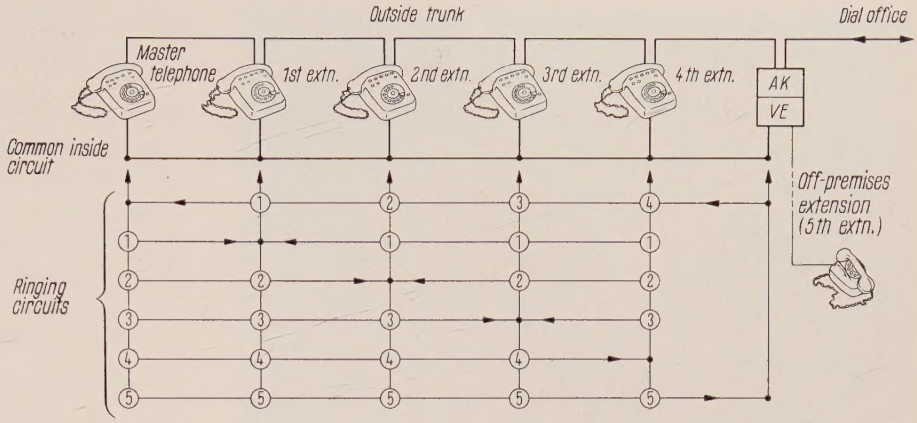
The user of the off-premises extension is able to call the master telephone by dialing a random digit and may then ask to be connected with another extension. To obtain the outside trunk he must first remove his handset and then briefly press the white button. If the trunk is already in use, he will receive busy tone in the form of a continuous hum. If he now dials a random digit before replacing the handset, a trunk-reservation feature (supplementary feature) will cause him to be automatically rung as soon as the trunk becomes available. On removing his handset anew he will receive dial tone from the public dial office and may commence dialing the wanted number.

When a REIHA PBX is used as a second PBX, no change in operating procedure is involved. The tie-line to the main PABX is occupied by pressing the trunk button. To obtain an idle trunk the user of the REIHA extension can now, depending on the type of main PABX, either press the white button (in the case of small Neha Relay-operated PABX's) or dial the trunk code (in the case of medium to large PABX's). The trunk call can be interrupted while a consultation call is made to any REIHA extension or any extension of the main PABX; it is also possible for the trunk call to be transferred to the consulted extension. If the main PABX has several outside trunks, the extension of the REIHA PBX can make a consultation call over a second trunk to an outside subscriber.

Individual charges covering calls made by REIHA extensions can be read. The master telephone is for this purpose provided with a resetting-type rate indicator, extension identification lamps are embodied in its ringing buttons, and a clearing lamp is provided (Fig. 5). The clearing lamp flashes to indicate the termination of

Fig. 3 Telephone of a REIHA 1/5 PBX

a long-distance call that has been originated by an extension. The rate indicator operates to special time pulses from the public dial office [4, 5].



AK Trunk terminal box
VE Relay box for off-premises extension
1 to 5 Ringing buttons

Fig. 4
Survey plan of Reiha 1/5 PBX with one off-premises extension. Any extension can be called from any other extension by pressing the appropriate ringing button

For trunk calls, extension telephones are in all cases fed from the battery of the public dial office or of the main PABX. In the case of Reiha 1/1 PBX's, a power supply unit (0.2 amp) inside the trunk terminal box or a storage battery supplies the 6-v d-c required for inside calls. If the commercial power supply breaks down, trunk calls can still be conducted at the master telephone or at the extension.

In the case of Reiha 1/2 and 1/5 PBX's, 24 volts is required for inside calls and is likewise drawn from a power supply unit or storage battery. If the feed current is drawn from a power supply unit and the commercial power supply breaks down, trunk calls can still be answered at the master telephone and the trunk can be used in either direction.

Table 1 shows the respective power supply units required for the various Reiha PBX's.

Reiha PBX	Power supply units	Supplementary features
1/1	6 v 0.2 amp	—
1/1	6 v 0.2 amp	with clockface rate indicator
1/2	24 v 0.4 amp	—
1/2	24 v 0.7 amp	with rate indication and one off-premises extension
1/5*	24 v 0.7 amp	—
1/5*	24 v 0.7 amp	with rate indication or one off-premises extension
1/5*	24 v 1.5 amps	with rate indication and one off-premises extension

* If 3 or 4 extensions are required, the Reiha 1/5 should be chosen

Table 1 Models of Reiha Pushbutton PBX's

If, in the case of battery-operated PBX's, the outside trunk is connected to an LB office or an off-premises extension is connected to the Reiha PBX, a ringing vibrator will be required for ringing the dial office and the off-premises extension. This may be accommodated in the trunk terminal box in place of the power supply unit.

Fig. 5 Master telephone of Reiha 1/2 PBX. It has a resetting type rate indicator and a clearing lamp for indicating the termination of long-distance calls made by extensions

Fig. 6 Telephone of a Reipos 2/5 PBX. The splitting buttons *T* are illuminated rotary pushbuttons that may be used to initiate the following three functions:
Splitting of trunk connection when extension user interchanges between two calls on two trunks
Indication of incoming trunk calls
Assignment of night service to a predetermined extension

Fig. 7 Telephone of REIPOS 2/10 PBX

REIPOS Pushbutton PBX's

REIPOS Pushbutton PBX's are adapted for two outside trunks and up to six extensions (REIPOS 2/5) or eleven extensions (REIPOS 2/10) (Figs. 6, 7). As in the case of REIHA models, the first digit in the type code denotes the number of outside trunks and the second digit the number of extensions. Each PBX also has a master telephone. Table 2 shows the various REIPOS Pushbutton PBX's available.

Here again the outside trunks are run through the trunk terminal box to each extension in turn and finally to the master telephone (Fig. 8). In contrast to REIHA PBX's, each extension is provided with an inside circuit of its own over which it can be rung and can converse. Besides the buttons for the two outside trunks, each telephone is also provided with respective line buttons giving accesss to the other extensions; a wanted extension is rung by pressing down the appropriate line button as far as it will go.

The idle or busy condition of outside trunks is indicated in the same way as with REIHA PBX's. When an extension user conducts a call, the green pilot lamp of his telephone burns steadily, while at all the other extension telephones the red busy lamp burns. Calls are transferred or inside, consultation and trunk calls conducted in the same way as with REIHA PBX's. Supplementary equipment for combined monitoring-and-talking, transfer of ringing, night service, as well as terminals for connecting up the PBX to a PABX can likewise be provided.

REIPOS PBX's permit the connection of two off-premises extensions. The first and fifth line buttons of the normal extension telephones give access to these off-premises extensions. If both the latter are provided with combined monitoring-and-talking privileges, the first is only able to enter calls in progress over its assigned trunk 1 and the second only calls in progress over its assigned trunk 2. A trunk call is entered simply by the extension user lifting his handset and dialing "3"; no monitor button is required.

Off-premises extensions can additionally be provided with a supplementary trunk reservation feature. If both trunks are found busy, the extension user can automatically reserve the first trunk to become available by dialing "4" while busy tone is still heard. Another supplementary feature permits trunk calls at one off-premises extension to be offered to the other off-premises extension without the aid of the attendant at the master telephone: all the extension user need do is press his white button and dial "2". To make an inside call to the other extension, the calling party must first lift his handset and then dial "2". By dialing "1" he will reach the master telephone.

The off-premises extensions of a REIPOS PBX may thus dial four respective code digits in order to initiate four particular processes:

Digit 1 To call the master telephone

Digit 2 To call the other off-premises extension and, after pressing the white button, offer a trunk call

Digit 3 To initiate monitoring of a call in progress on the outside trunk

Digit 4 To reserve the next outside trunk that becomes free. The white button must be pressed beforehand.

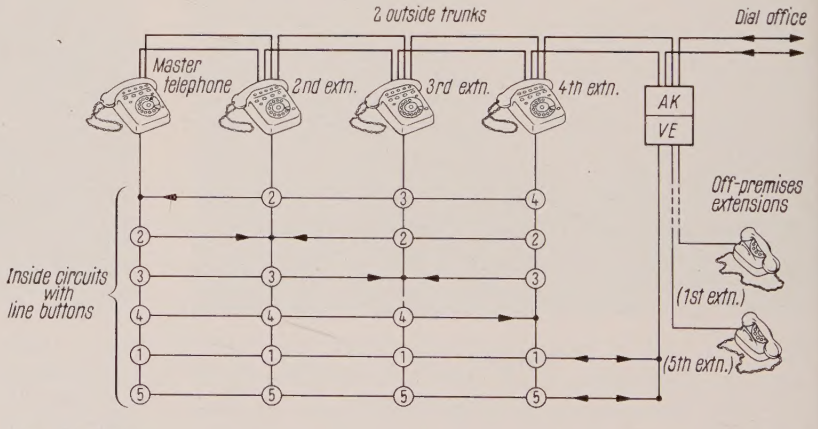


Fig. 8 Survey plan of a REIPOS 2/5 PBX with two off-premises extensions. The inside circuits are shared by all extensions and serve for both ringing and talking

The same rate indication facilities may be used for Reipos PBX's as for Reiha 1/2 and 1/5 PBX's (Fig. 9).

If the commercial power supply breaks down in the case of a PBX that is fed from a power supply unit, incoming trunk calls can be answered at the master telephone and both outside trunks can be used for making calls from the master telephone or any extension located on the premises. During a power outage it is naturally no longer possible for trunk calls to be transferred to extensions or for inside calls to be conducted.

If the PBX is connected to an LB office, its own power supply will be used for feeding in the case of trunk calls. As a rule the power will be drawn either from the CB of the public dial office or from the power supply of the main PABX, if any. If a ringing vibrator is used, the same applies as has already been stated in connection with Reiha PBX's.

Table 2 shows the respective power supply units required for the various Reipos PBX's.

Fig. 9 Master telephone of Reipos 2/5 PBX, with rate indicators

Reipos PBX*	Power supply unit	Supplementary features
2/5 and 2/10	24 v 0.7 amp	—
2/5 and 2/10	24 v 1.5 amps	Off-premises extensions or rate indication
2/5 and 2/10	24 v 2.5 amps	Off-premises extensions and rate indication

* If less than 5 extensions are required, Reipos 2/5 should be chosen; if from 6 to 9 extensions are required, Reipos 2/10 should be chosen

Table 2 Models of Reipos Pushbutton PBX's

The use of circuits with improved transmission characteristics and of redesigned telephones secures not only easier handling and superior operating reliability, but also additional service facilities.

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Mimic Diagram Control — A new Control System for Switching Stations

By Ernst Weiland

The introduction of the switching transistor within the framework of the Simatic* system [1] has resulted in further progress in the development of centralized local control of switching stations [2].

Below is a detailed description of the mimic diagram control system and its mode of operation.

Construction

Fig. 1 shows the basic arrangement of mimic diagram control. The control initiating and revertive signalling equipment is incorporated in the control desk. A further control unit is provided for local operation. Control impulses sent from these points pass through the Simatic control unit which incorporates protection against incorrect switching and automatic safety arrangements. The impulse is passed through this unit only if all interlocking conditions etc. have been met. It is then fed into the signal amplifier, amplified and transmitted to the high-voltage switchgear. The particular position of the high-voltage switchgear is transmitted to the control points and to the Simatic control by the revertive signalling equipment.

* Trade-mark

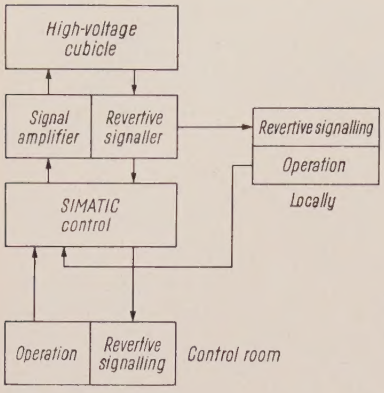

Fig. 1 Basic arrangement of the diagram control

The dimensions of the control boards and desks are determined by the size of the control and measuring equipment. The use of a luminous momentary-contact pushbutton in place of a control discrepancy switch and the transfer of some of the functions of this to the control system have made for a far more compact arrangement of the control and revertive signalling equipment than was previously the case. With mimic diagram control it is possible without selection to control extensive switching stations from a single desk panel.

Desk panels comprise the main part of the mimic diagram control. In appearance they are distinguished only by the easily detachable cover plates and can be arranged side by side in mosaic pattern as required by the layout of the station to be controlled. The mimic diagram and the luminous pushbuttons are accommodated on the cover plates. The panel width of 2.4 in. is determined by the size of the desk panel which is 2.4×1.5 in.

The construction of the mimic diagram control on the building-block system affords a number of advantages, particularly in the event of modifications to the switching station, since the cover plates can be quickly exchanged or empty panels replaced by others fitted with the required item of equipment.

SIMATIC control

Uniform building blocks have been used both for control initiation and for the actual control system. They comprise: the control building block, the incorrect switching protection, the false signal blocking unit and the automatic safety unit.

These building blocks consist of individual SIMATIC components [3] which are interconnected. The wiring is covered and thus protected against mechanical damage. Leads to be brought out are connected to a plug-in socket strip.

The building blocks within the actual unit forming part of the same circuit are plugged in and interconnected. Leads for the external connections are taken to a tag-end connector block.

The control building block fulfils three functions, one block being provided for each isolating switch or circuit breaker to be controlled.

Function No. 1: Storing of the momentary control impulses.

Function No. 2: Selection of ON or OFF. This is necessary because the control pushbutton effects only a change in the position of the switch.

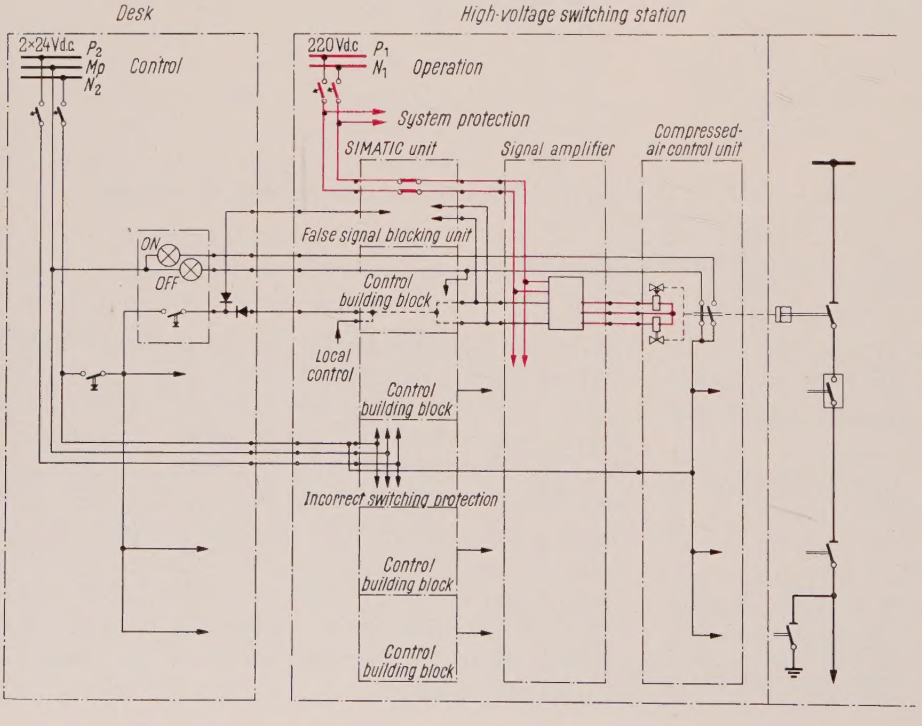

Fig. 2 Simplified diagram of a circuit

Thus if the isolating switch or circuit breaker is in the OFF position, it is closed, and if it is in the ON position or in a fault position, it is opened.

Function No. 3: Prevention of duplicate operation of switches within the circuit.

The control building block is always of identical construction, irrespective of whether it is intended for application in a high-voltage or extra-high-voltage switching station.

The building block for incorrect switching protection fulfils the interlocking requirements within the circuit, one only being allocated to each circuit.

The third building block of a subassembly is the false signal blocking unit. This serves to supervise the incorrect switching protection and the control and, in the event of a fault developing, prevents undesirable switching operations from being carried out. Facilities are provided for making a functional check on the false signal blocking unit.

In addition to the normal interlocks for the individual circuit, protection is required against incorrect switching for the entire station, this applying particularly to the bus sectionalizers and the bus ties. These requirements are met by the building block for automatic safety. Only one of these is needed in each switching station and the unit is designed specially in each case.

The system protection with tripping, rapid reclosure, etc., is superordinated and is blocked by the incorrect switching protection only where required, e.g., in the coupling unit.

Signal amplifier and revertive signalling device

The control impulses which are selected and checked in the Simatic unit are amplified in the signal amplifier. At present, coupling relays are still employed to metallically isolate the control and operating voltage. All relays associated with one circuit are likewise combined to form a unit with a tag-end connector block. If full protection is to be provided, the pilot switch must fulfil comprehensive interlocking conditions. For the mimic diagram control only one NO contact and one NC contact (or a transfer contact) per high-voltage switch are required, irrespective of the extent of the interlocking system (Fig. 2). Particularly suitable for correct indication of the switch positions is the Siemens compressed-air control unit in which the operating valves and the revertive signalling device are combined [4, 5].

Operation of the mimic diagram control system

A typical mimic diagram control unit is shown in Fig. 3. On this is arranged a momentary-contact luminous push-button for every switch to be controlled. The push-button serves to give both the ON and the OFF control impulse, indication of the ON and OFF switch position being provided by a red and a white lamp respectively.

To prevent maloperation of the control system due to carelessness, e.g., placing of objects on the pushbuttons, each circuit incorporates a release button with which every associated switch can be controlled one after the other.

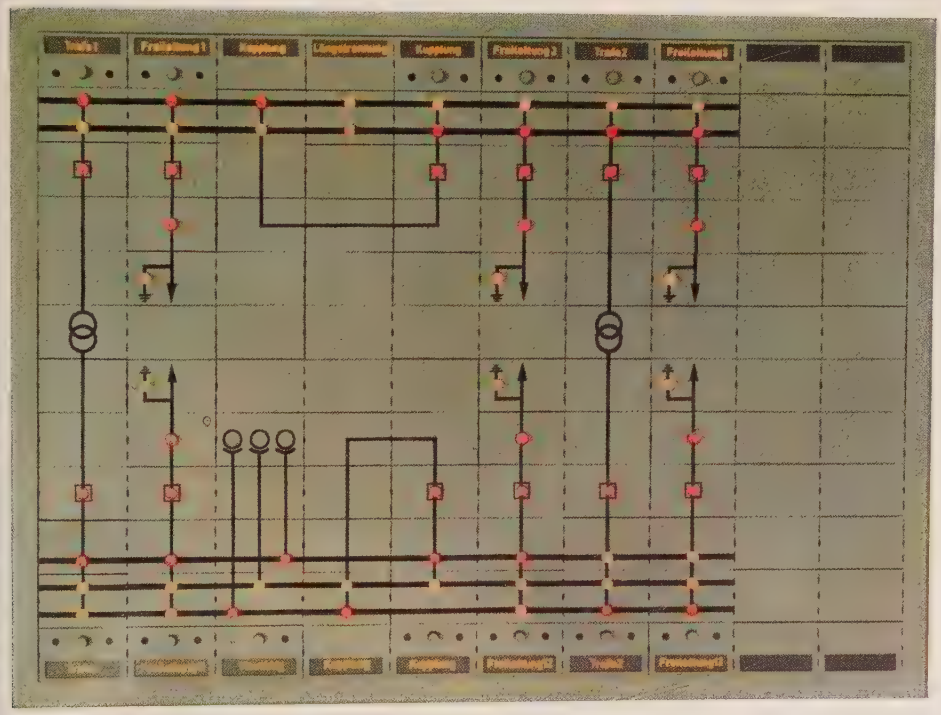

Fig. 3 Typical plate for a control desk

Since every switching impulse is stored, it is sufficient to give a control impulse with the release and operating button. If it should be necessary to extend the operating time beyond the duration of the signal, this can be achieved by continuously pressing the corresponding button.

The entire control and revertive signalling system can be switched on and off by means of a main switch. Thus the attendants can, for instance, block the control when leaving the control room.

Local control is also electric and incorporates all the building blocks. The individual valves for compressed-air operation are blocked for normal remote operation and are intended only as a standby for emergencies.

In the event of a fault developing in the SIMATIC component the attendants are not expected to search for the defect inside the building blocks. The fault can be located by drawing out the plug-in building blocks one after the other until the fault signal disappears. This happens as soon as the faulty block is removed. When a new building block is fitted the control system is immediately ready for service again.

The wiring outside the building blocks has been simplified, and the location of faults in this part of the control system made much easier.

Power supply

In accordance with standard practice the control and signalling circuits are fused individually in all branches. Here a distinction is made between the control voltage and the operating voltage. Faults in the circuits are detected selectively and are restricted to the circuit affected. The 24-V d.c. control impulses are transmitted to the signal amplifier on the input side of the operating coils.

The control operation is then completed with the usual operating voltage of up to 220 V. This voltage is likewise applied to the tripping circuit of the system protection so that it remains effective in the event of faults in the control and signalling circuits.

Supervisory equipment

A series of target indicators serves to supervise the mimic diagram control. Generally there is a collective audible and visual alarm for all faults. The exact location of the fault is then indicated within the mimic control diagram.

Assume for instance that the protective circuit breakers for the control and operating circuits trip out. The exact location of the fault is indicated by the extinguished luminous pushbuttons or circuit inscription.

Automatic tripping of a circuit breaker by the system protection is indicated by the red flashing light of the station inscription. This also lights up when the entire control and revertive signalling system is switched off. The ON control impulse for the circuit breaker cannot be given until the flashing light has been acknowledged. The object of this is to ensure that the attendant first of all acknowledges the fault and does not inadvertently close the circuit breaker.

Two further targets are provided on the desk panel bearing the circuit inscription. One signals internal faults

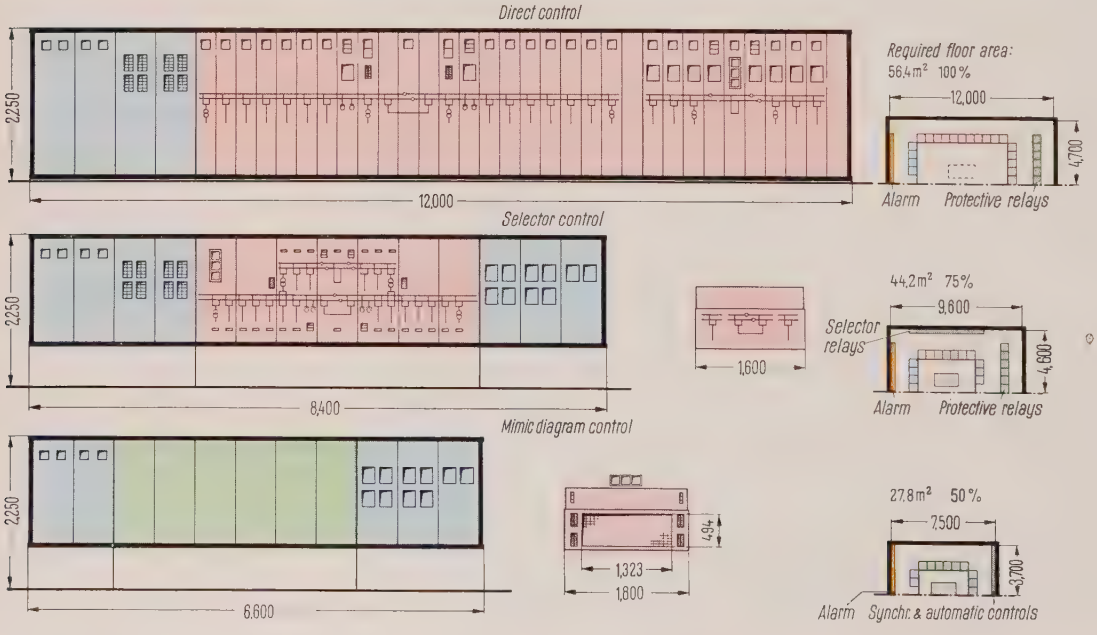

Fig. 4
Comparison of the space requirements of centralized local control systems (Dimensions in mm; 1 mm = = 0.03937 in.; 1 m² = = 10.76 sq. ft.)

in the control or incorrect switching protection circuit, the other indicates the operating or fault positions of the isolating switches. The second indication provides an accurate check on the switching operation. A burnt-out lamp can be identified immediately and does not simulate a fault position.

Metering

In the reduction in size of the control and revertive signalling part attention must be paid to the metering circuits and equipment. In principle, this could be left as before and the instruments arranged on a separate instrument board.

It is, however, expedient to combine the metering instruments with the mimic diagram control, i.e., with the control and revertive signalling sections. The panel width of 2.4 in. lends itself well to the fitting of standardized instruments 1.9×1.9 in. and 0.9×1.9 in. The scales of these instruments are also suitable for reading accurate values. On account of the short distance between the eye of the viewer and the inclined top of the desk, these small instruments have the appearance of being larger, compared with the usual instruments and arrangement.

If it is intended to take regular readings and to enter them in a log book, e.g., to evaluate the figures for statistical purposes, it is expedient to incorporate in the control system an automatic unit for evaluating measurements. This method of digital measurement reliably and rationally performs the work carried out by the attendant. Details of colour recording of values exceeding set limits, the extra-cyclical recording of all measured values and relay operation times following system faults and of the remote transmission of digital values can be obtained from the references at the end of this article [6, 7, 8, 9].

Space requirements

The space requirements for the direct type of control, the selector control and the mimic diagram control are shown in Fig. 4. The basis selected for comparison is a medium-sized transformer substation.

To make the comparison logical, the U shape has also been retained for the mimic diagram control. In actual practice the entire control system would be arranged differently since the room in which the control desk is located is considered to be too small.

The required floor area, which has been assumed at 100% for the direct type of control, is reduced to 75% in the case of the selector control and to 50% in the case of the mimic diagram control.

In conclusion it should be mentioned that in large control rooms the technique of the selector control can be applied to the mimic diagram control, an arrangement which provides many other interesting possibilities.

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Walkie-Talkie for Fiery Mines and Industrial Plants Exposed to Explosion Hazards

By Gerhard Dropmann and Walter Pinkernelle

Particularly in the mining industry there is a frequent demand for temporary telephone links for use, say, during the repair of mining equipment, in the event of accidents, and also where complicated installation work has to be performed over a large area. The provision of a wire telephone circuit or other conventional communications link would here call for a relatively large amount of line plant, which would mean unneccessary expenditure in view of the temporary nature of the requirement.

Telephone or signaling equipment is also sometimes required for communication between engine house and mine cage. Several types of equipment have already proved their value for this application and operate by way of the hoisting rope or the other cables suspended in the shaft. Such facilities have, however, a number of disadvantages. For instance, the rope cannot be used while it is being changed because the closed loop consisting of the top rope and counterbalance rope will here have been interrupted. Yet particularly in changing a rope, or if a rope breaks, intercommunication between all points of the shaft will be essential. The same applies when a shaft is sunk, for no closed loop will as yet exist.

In plants exposed to explosion hazards there are also a variety of instances where a telephone link is urgently

required but the installation of explosionproof leads and distribution boxes would come too expensive. There are many special cases, too, where explosionproof walkie-talkie equipment will be of advantage: in the case of balloon ascents, for instance, communication between the occupants of the gondola and ground stations is highly desirable. The equipment in the gondola must likewise be explosionproof because, in landing or when there is a sudden rise in temperature, the gas will stream out of the balloon and is liable to be ignited by possible sparks caused by switching operations. In all such cases walkie-talkies have been shown in thoroughgoing trial workouts to offer an ideal solution if suitably adapted to the conditions on hand. In the present paper it would thus appear advisable first of all to treat the general requirements imposed by plants on such equipment and then to discuss its wave propagation characteristics; in conclusion a description will be given of the constructional design and operating principle of the new walkie-talkies designed by Siemens & Halske for fiery mines and all types of plants exposed to explosion hazards.

Requirements imposed by plant

Walkie-talkies are today widely used in traffic control applications, in which field they have amply demonstrated their value. Their use in mining or industrial plants exposed to explosion hazards demands, however, that they themselves should not constitute a hazard. Since switching operations are at times liable to create a spark that could ignite any nearby mixture of gas, there is a certain danger of explosion. This can be overcome by enclosing the equipment in a case that provides positive protection against the dangerous effect of sparks or the development of heat. The antenna power must also not be allowed to rise to a level that could produce a spark. As no reliable values have been set for r-f circuits, their power must not be rated higher than admissible to secure intrinsic-safe conditions. Circuits in which the power does not rise to sparking level in the event of a short-circuit condition or a wire breakage are considered intrinsic-safe.

The necessary safety measures are set down in VDE specifications 0170 and 0171. Equipment to be used in plants exposed to explosion hazards or firedamp must be tested by the appropriate authorities – the Physikalisch-Technische Bundesanstalt Braunschweig and Berggewerkschaftliche Versuchsstrecke Dortmund-Derne – with respect to adherence to VDE specifications and whatever mining safety specifications these do not cover. In spite of these exacting requirements, the equipment must also be capable of operating for a sufficient length of time. Measures must also be instituted which afford the equipment a large measure of protection against damage due to improper handling or corrosion.

Foreman communicates by walkie-talkie during repair work in a shaft

Wave propagation and range

In choosing the wavelength, due consideration must be given to the respective propagation conditions for the various types of application. In the uhf region serious attenuation is encountered, especially in underground mines, as the result of absorption. Low frequencies cannot be used at such locations on account of the size of the antennas that would be required. In underground galleries, which may be regarded as waveguides from the aspect of transmission engineering, low frequencies are unable to propagate as free waves and have to be transmitted over a physical circuit. Uhf waves, on the other hand, have proved optimum with respect to propagation conditions and engineering effort for a great many plants exposed to explosion and firedamp hazards.

For mining applications a reservation must be recorded with respect to propagation capabilities, for waves of high frequency are known to have quasi-optical propagation characteristics. The usually horizontal soles and galleries of a mine in most cases have numerous bends and do not run in a straight line and on the same plane. Thus it is not always possible to use uhf

radio equipment. Uhf radio is, moreover, greatly impaired in soles and galleries by cross section obstacles produced by transportation media such as mine railways, etc. It is not possible to make positive predictions regarding range which would have any general validity because the range will additionally depend to a large extent on the geological structure of the hill.

Conditions in a vertical shaft are more favorable. In line with its purpose the shaft will naturally be constructed without a bend, although slight bends may develop over the years due to shifts inside the hill. Extensive measurements performed in the shafts of ore, potash and coal mines have shown that good speech intelligibility is in most cases secured between the pithead and the various soles. The iron reinforcements used in the construction of the shaft and the facilities for guiding the cage were found to be responsible for the absorption of only a small amount of the energy of the r-f field, although absorption does take place in moist zones within the rock. In shafts where large arteries of water flow down to the lowest point of the shaft, intelligibility will exhibit certain deficiencies.

Short-time fading phenomena are also likely to be encountered as a result of the change in polarization brought about by the material used in the construction of the shaft and by the rotation of the polarization plane of the waves. A normal receiving antenna will respond only to the component of the field strength that oscillates in the direction of the antenna and not to the other component that is perpendicular to it. The amplitudes of the two components also vary with the oscillating direction of the overall field strength. As they vary in the opposite sense the field strength received by the antenna may drop below the admissible limit of the receiving field strength. Even then reception will frequently be possible after suitably tilting the antenna.

Difficulties of this nature do not exist where radio equipment is used in industrial plants exposed to explosion hazards. Buildings, factories, masts, and other objects located between the transmitter and the receiver have practically no effect on the short-range propagation of uhf waves. Owing to the numerous reflections it is in most cases even possible to pick up signals behind such buildings and similar structures. Although obstacles frequently act as secondary radiators, so giving rise to distinct points of destructive interference, it is usually possible to circumvent them and find a point of maximum field strength.

The range attained in uhf bands therefore depends on a great many factors. The 4-m band (68 to 87 mc) has, for instance, proved to be the best for shafts. Adequate speech intelligibility has here been secured with depths down to 3,300 ft and more. For built-up factory compounds the range depends on the height of the antenna. The distance between two ground stations can usually amount to as much as 3 miles. Up to $9^1/_2$ miles can be spanned if the antenna is mounted higher, or if a mast antenna is used. In experiments with balloons, proper speech intelligibility was secured across 38 miles with a balloon at a height of 8,200 ft.

Design and operating principle

The basic unit of equipment is the well-proven uhf walkie-talkie of Siemens & Halske[1]. This unit, which was designed as a handy item for normal applications, had to be modified to meet the more exacting VDE specifications for plants exposed to explosion hazards. The danger of mechanical impact, which is yet another hazard in mining, demanded an extremely rugged constructional design with all attachments given maximum protection (see illustration). To overcome the danger of sparking or heat development during operation, the main equipment is encapsulated in a pressure-tight cylinder that exhibits particularly good static properties in the presence of internal explosions.

The cylinder is closed with a lid with finely machined surfaces that fit into it. The lid embodies the switches, microtelephone and antenna required for operation of the equipment. A separate safety-type terminal box on the lid is used for the connection of the microtelephone. As the lead-ins of the antenna and the switches are sealed for a specified length, any inflammable gas in the interior will positively lose its ignitability as it passes through this sealed section. The same applies to the flange between the cylinder and its lid. It is worthy of note that the pressure-tight section of the cylinder is not only proof against firedamp and explosion but, as the result of an additional rubber gasket, also against pressure water. Thus the built-in uhf equipment is largely protected against the effects of moisture and corrosion as well. Inside the cylinder there is also a compartment for the storage batteries which is partitioned off from the pressure-tight compartment. The batteries are attached to the bottom lid and inserted in the cylinder together with it. The lid has a bayonet lock. The connector for connecting the batteries is so designed that any sparks that may develop from improper on/off switching cannot cause ignition.

The weight of the equipment depends primarily on the period for which it is required to operate. Walkie-talkies used for normal applications can be operated for nine hours at a time, which is usually sufficient in mines and plants exposed to explosion hazards. If a longer period of operation is required, new batteries should be inserted. A charger, to which two sets of batteries can be connected at the same time, is provided to insure that the equipment will be ready for use at any time. Since the maintenance stations of most plants are equipped for

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lead-acid storage batteries, a commercial type that does not require any form of special handling is here chosen.

The antenna power of 0.25 watts is intrinsic-safe, which means that this energy is incapable of igniting gas of any composition in the event of a short-circuit or short-to-ground.

Transmitter and receiver are permanently tuned to a frequency within one of the industrial channels in the 156 to 174 mc or 68 to 87.5 mc bands allocated by the West German Post. Since only a single crystal-controlled frequency has to be set, it has been possible to achieve great sensitivity and selectivity and to simplify manual control considerably. An input voltage of $< 1\mu v$ is already sufficient to obtain a signal-to-noise ratio of 20 db. At $\pm$ 100 kc off resonance the selectivity is at least 80 db. A subsequent change of frequency is readily possible. The walkie-talkie operates with phase modulation, this being particularly favorable with respect to immunity to interference signals. A limiter circuit holds the audio power practically constant irrespective of the receiving field strength. As no separate volume control is required, manual control is greatly simplified. The walkie-talkie is provided with a carrying strap, weighs 27 lbs, and can be operated as the user walks along.

As the walkie-talkie is designed with subminiature components it has been possible to keep the size of the firedampproof and explosionproof cylinder small. Tubes, transistors and germanium diodes are used. The anode voltage is generated by way of a transistor transformer circuit that is devoid of mechanically actuated parts.

There are two switches. When one – the battery switch – is pressed, current is fed to the equipment. When the other – the function selector – is set to its middle position, the equipment is ready to receive and any incoming call will be announced by a buzzer. The two end positions of the selector are respectively for calling the wanted party and for talking. Like most walkie-talkies, this model also operates on a half-duplex basis.

A rugged watertight and dusttight handset of the type conventionally used for mine telephones is used. As the circuits leading to the handset are intrinsic-safe, it is also readily possible to use any other suitable headset such as headphones with a throat microphone. These should be chosen in cases where it is required that the user retain both hands free during listening.

The walkie-talkie has already been approved for fiery mines by the Berggewerkschaftliche Versuchsstrecke (Miners' Union) in Dortmund and for plants exposed to explosion hazards by the Physikalisch-Technische Bundesanstalt in Braunschweig.

It can thus be used in underground mines and in plants exposed to explosion hazards of the classes 1 to 3 n and of the ignition classes G1 to G5 as per VDE specification 0171, i. e. in any plant explosed to explosion hazards. It safitises a long-existing requirement in that it is the very first telephone equipment to meet the safety specifications for all gases and vapors of explosion class 3.

The firedampproof and explosionproof model is considerably more expensive than the standard model on account of the greater outlay. To save expenditure it is in many cases the practice to use explosionproof equipment together with standard equipment, in which case the latter must naturally be accommodated in a room that is safe from firedamp or explosion hazards.

Fields of application

The installation of a telephone system in plants exposed to explosion hazards demands not only expensive equipment but also involves considerable outlay for line plant and its installation. This outlay is not justifiable unless the equipment is to be used for many years. If it is only required during repairs, this will not be the case and it will be more economical to use the walkie-talkie here described. The same applies in cases where a communications link is required between structures such as high towers, gasometers, petroleum tanks, etc., or between industrial plants that are located far apart such as oil pools, tank depots, or for public highways or vehicles and ships operated or loaded with explosive fuels.

For underground mines the walkie-talkie will be used for the most part in the shaft, where it will find useful application in sinking the shaft, changing the hoisting rope or the cage guides, or in performing other repairs, but particularly in cases where bulky items of equipment or mechanical parts have to be transported. During shaft inspections the walkie-talkie can be used to direct the operation of the cage. Any trouble that is discovered can be immediately communicated to surface so that remedial action can be taken.

The walkie-talkie is also suitable for telephone communication between cage and engine room during normal operation provided that a trial workout has previously shown that reliable communication is possible at any time throughout the entire depth of the shaft. The transmitting station should here be permanently installed so that improvements can be secured by the use of suitable antenna arrangements if fading is encountered.

Its built-in signal generator (buzz tone) can also be used without modification for signaling purposes. If desired, the tone can be boosted to the required volume by means of an amplifier, or the amplifier may be used to trigger a single-stroke bell or emergency alarm.

If the propagation conditions of a shaft permit, the walkie-talkie provides the simplest telephone and signaling link between the traveling cage and the engine room. It involves no major installation work and is more immune than other systems to mechanical damage, moisture and corrosion. It can be maintained in surface workshops without any great loss of time.

Large Rectifier Transformers

By Helmut Feyertag

The field of application of direct current is expanding constantly and is accompanied by the erection of new and larger rectifier plants. Since the d.c. output voltage required is generally lower than that of the a.c. supply voltage, the role of the rectifier transformer is very important. It forms the link between the three-phase a.c. system and the d.c. system and in some cases has to meet far more stringent requirements than ordinary system transformers.

Development in the field of rectifiers has progressed from mechanical contact rectifiers to the new silicon rectifiers which are capable of very high outputs. The general trend on the load side, particularly in the case of electrolytic plants, is towards higher currents and lower operating voltages [1]. This makes it necessary to construct rectifier transformers for secondary currents of several thousand amperes (rms). At the present time rectifier transformers are being manufactured with a primary rating as high as 16.5 MVA and secondary phase currents of 12 kA. Fig. 1 shows a complete transformer with a slightly lower rating (13 MVA) for a silicon rectifier plant.

In rectifier engineering, the mercury-arc rectifier has retained its place alongside the mechanical contact rectifier and the silicon rectifier. It is mainly used for high voltages and relatively low currents. Since this article is restricted to rectifier transformers for high secondary currents, it does not cover transformers for mercury-arc rectifiers.

Conditions governing rectifier operation

To ensure satisfactory operation of the rectifier plant, the rectifier transformer is required to fulfil certain conditions with respect to the voltage and the short-circuit strength.

Voltage

The two main circuit arrangements employed for rectifier plants, the double-star circuit with interphase transformer and the three-phase bridge circuit, generally make it necessary to use three-winding transformers. The interphase transformer circuit provides better utilization of the transformer only if two phases of both secondary stars can in each case be arranged on one limb. In the three-phase bridge circuit a twelve-phase effect on the a.c. system can be obtained by providing two second-

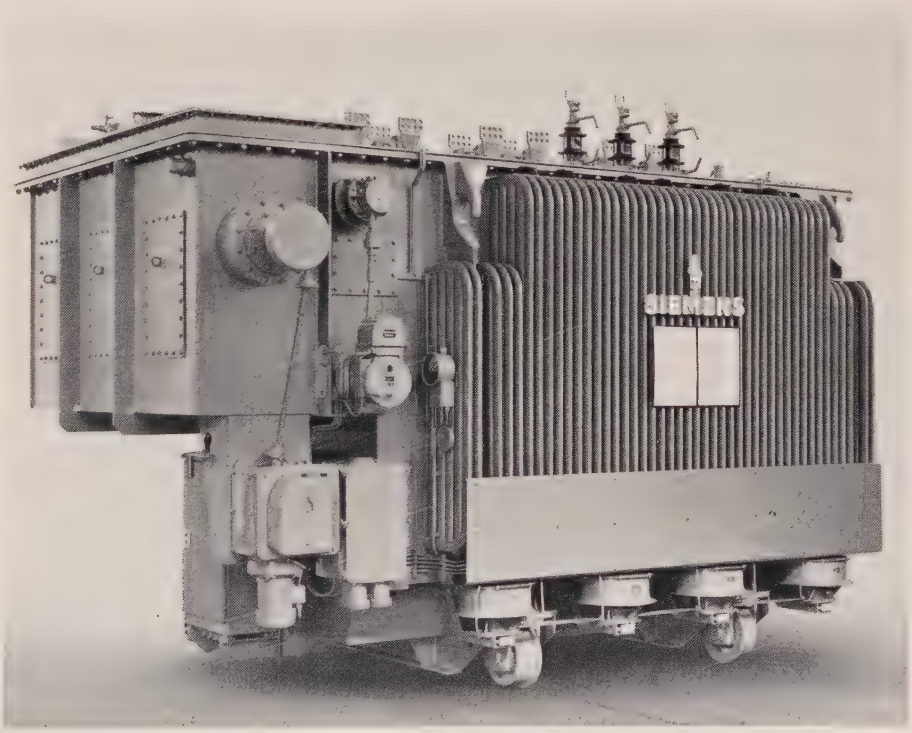

Fig. 1 Rectifier transformer with on-load tap changer in each phase on the high-voltage side and off-load delta-star changeover switch. Type rating 13 MVA

ary windings and connecting one in star and the other in delta.

In the case of transformers with two secondary windings, the line-to-line voltages of both systems must be the same. With a rectifier circuit incorporating an interphase transformer this can easily be attained by giving both secondary windings the same number of turns. With a bridge circuit having a twelve-phase effect on the a.c. system, the necessary ratio of the turns of $1 : \sqrt{3}$ appreciably limits the selection of the voltage per turn. This ratio is brought about by the fact that in the winding connected in delta the phase voltage is equal to the line-to-line voltage, whereas in the winding connected in star the phase voltage is equal only to $1/\sqrt{3}$ of the line-to-line voltage.

A further condition is that the impedance voltage between the primary side and one of the windings on the secondary side must be equal so that the secondary voltages of both systems are also the same at full load. This condition has an appreciable influence on the design of the transfomer and makes necessary a high degree of accuracy in manufacture.

On-load tap changing

To permit compensation of a.c. voltage fluctuations and adjustment of the d.c. voltage, particularly in electroplating operation, transformers are frequently provided with a tap changer. Depending on its design, this makes it possible to vary the secondary voltage on load in 10, 12, 2×10 or 2×12 steps. The tap changer is driven by an electric motor and can also be operated from the control board. For special operating conditions a larger number of steps can be selected. Since in many cases a very wide and finely stepped voltage range is necessary, particularly for the polarization of electroplating baths, it has proved expedient to provide facilities for reducing the secondary voltage, e.g., in 2 × 24 steps, to a third of the rated value. This consists in additional delta-star changeover of the high-voltage winding. On account of the low number of turns on the low-voltage side, the ratio is generally changed by switching in and out turns on the high-voltage side. For this reason the type rating of the transformer is determined essentially by the voltage range. The range, especially where delta-star changeover is provided, generally traverses about 73% of the lowest secondary voltage. It can be extended to a ratio of, for instance, 1:3 if a wide voltage range is required, but it is not possible to interrupt operation to change over off-circuit from delta to star.

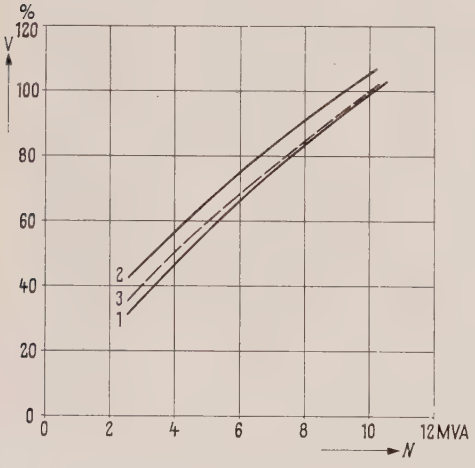

Fig. 2 Total losses V of rectifier transformers at rated current as a function of the rated output N. The losses at 10 MVA in curve 3 are equal to 100%.

The delta-star changeover switch is arranged separately from the tap changer and can be operated only when the transformer is isolated from the supply. Where only infrequent switching is required, the tubular type should be selected and for frequent switching the drum type. In the latter case it can be operated by a motor to permit remote control from the control board or automatic changeover when the last step of the delta range has been reached.

The design of a rectifier transformer with a tap changer affords important operating advantages. Of course the selection of a larger type rating, made necessary by the fitting of a winding with tappings, especially in the case of three-winding transformers, increases the iron and copper losses. Fig. 2 shows the difference in the total losses of transformers with and without tap-changers.

Where the primary voltages are high and the voltage ranges wide, e.g. from 100% to 0% of the secondary voltage, it is generally advisable to carry out the adjustment of the voltage by means of an auto-transformer with a tap changer, instead of on the rectifier transformer. Both transformers can be combined to form one unit and built into the same tank. The advantages of this type of construction are smaller space requirements, compared with separate installation, and a higher degree of operating reliability since the auto-transformer on its own is not short-circuit proof. The arrangement of the two transformers in one tank precludes the possibility of a short circuit across the secondary terminals of the auto-transformer.

Phase shifting

Where rectifier units operate in parallel, it is possible to reduce the ripple content of the system, i.e., a 24-phase or even higher effect can be obtained on the a.c. system. To do this it is necessary to rotate the vector of the secondary voltages of the individual transformers by a definite amount, a condition which, however, has an appreciable influence on the design of the windings. The shifting is attained by constructing the high-voltage winding in two sections in a manner similar to a zig-zag circuit. The winding section on one limb is in each case connected to the winding section on the other limb. The output

voltage vector can be displaced in a positive or negative sense with respect to the input voltage vector depending on the type of connection used. The size of the winding sections is determined by the angle required. For a rotation of 15° the windings must, for instance, be designed for 81.64% and 29.85%, respectively, of the rated voltage.

Short-circuit strength

The short-circuit stresses which the transformer must be capable of withstanding in operation have a decisive influence on its electrical and mechanical design. This applies particularly to transformers for mechanical contact rectifiers. These are protected by short-circuiters, which, in the event of faults, short-circuit the secondary side of the transformer. Thus, until the a.c. circuit breaker trips, the full short-circuit current flows through the transformer. In some cases, this protective system is also employed with silicon rectifiers. Here, however, the short-circuiters operate far less frequently than is the case with contact rectifiers since they have only to provide protection against external short circuits.

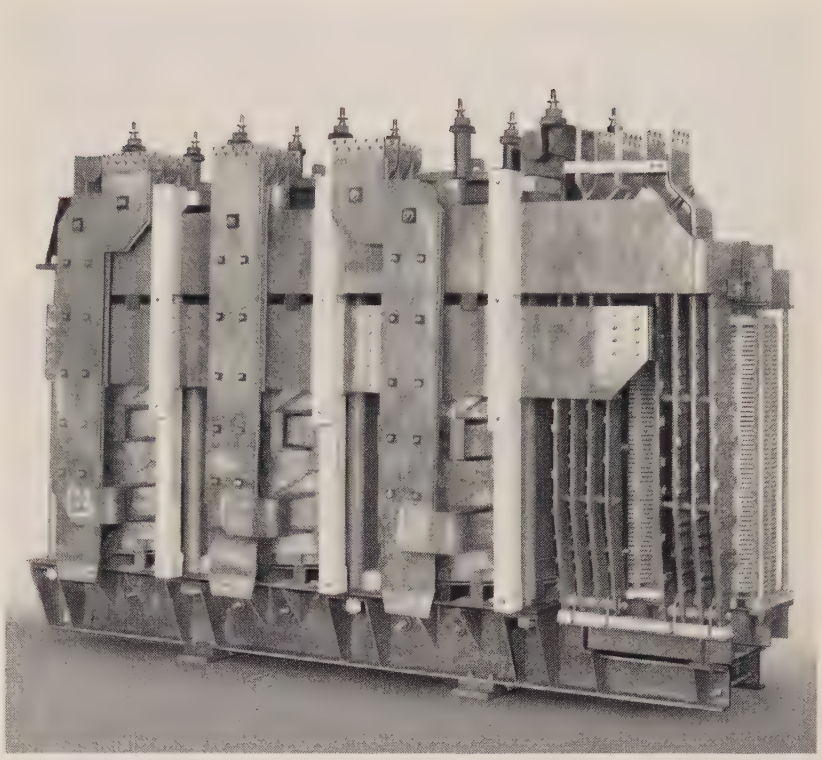

Fig. 4 Rectifier transformer with built-on interphase transformer for 270 V and 25,000 A d.c. View of the main and neutral bars of the low-voltage winding

High impedance voltages would reduce the short-circuit current and thus the mechanical stresses which the transformer has to withstand. However, this is generally not possible since high impedance voltages not only reduce the efficiency but also have an unduly great effect on the voltage characteristic of the rectifier and on the power factor. Fig. 3 shows the decrease in efficiency as a function of the impedance voltage for three transformers with different ratings. In view of this, the transformers must be designed to withstand the high short-circuit stresses expected. There is no danger of unduly high temperature rise in the winding on the development of a short circuit since the duration of this does not generally exceed 100 milliseconds.

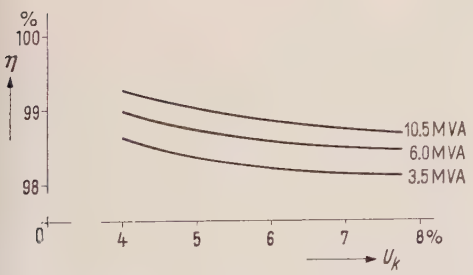

Fig. 3 Efficiency of rectifier transformers with on-load tap changers as a function of the impedance voltage u_k

Construction of the rectifier transformer

So far we have dealt with the requirements which a rectifier transformer has to meet. In the following we will discuss the influence which these have on the construction of transformers and how they are taken into account. The examples considered are taken mainly from types for use in electrolytic plants in conjunction with mechanical contact rectifiers or silicon rectifiers.

Secondary side

The secondary side of the transformer generally consists of two low-voltage windings and has to be designed for a low phase voltage and high currents. The low number of turns made necessary by the low voltage have an appreciable effect on the design of the transformer, particularly where a bridge circuit is employed. Since in this case one winding is connected in delta and the other in star, the ratio of the turns of these windings must be $1 : \sqrt{3}$, otherwise the line-to-line voltages of both systems will not be equal. In the low turn number range, however, only a few numbers of turn pairs adequately meet these requirements, e.g., 4 : 7, 7 : 12, 8 : 14. Thus the dimensions of the cores

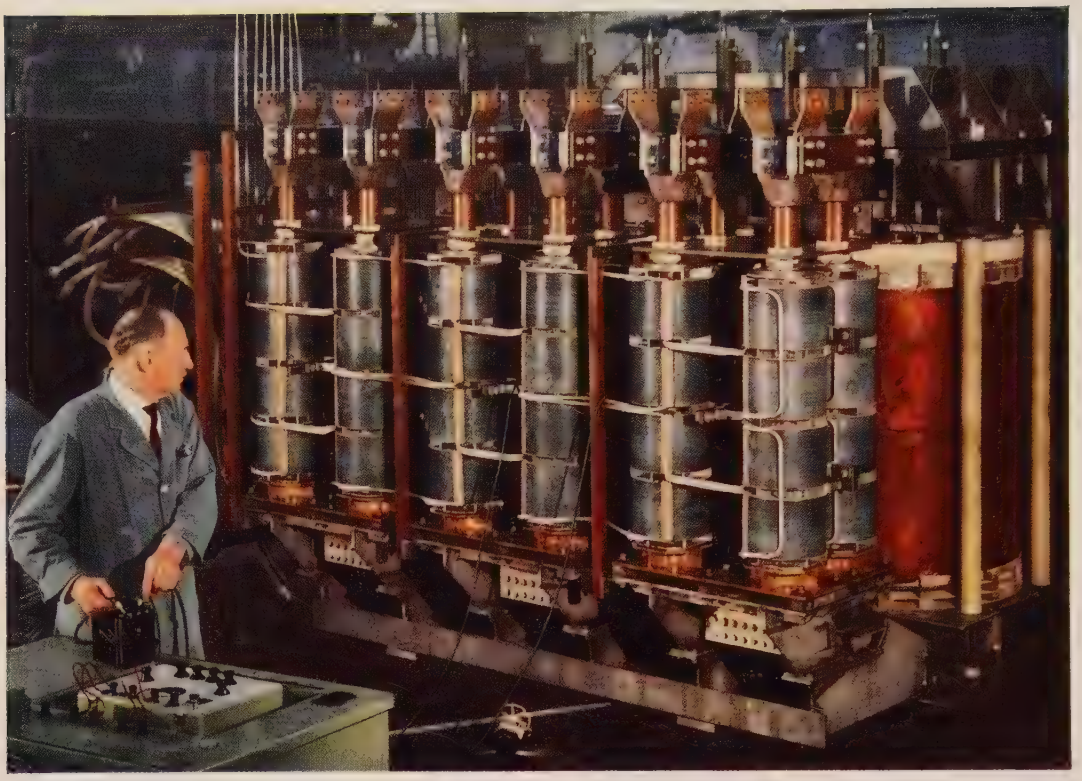

Fig. 5 Rectifier transformer with built-on transductors for 325 V and 26,000 A d.c. (three-phase bridge circuit)

of these transformers do not change with the output in accordance with known laws, but are determined by the magnitude of the secondary voltage and the corresponding ratio of the turns. The varying secondary voltages frequently make it necessary to employ different core dimensions, although the output is the same; this is brought about by the fact that there is an appreciable difference between the numbers of turn pairs which can be considered. If both secondary windings are connected in star, the matter is somewhat simplified; since here, too, it is in many cases essential that even numbers of turns be employed, the dimensions of the core are likewise dependent on the magnitude of the secondary voltage.

The second parameter on the low-voltage side which influences the design of the transformer is the magnitude of the secondary current – at present rectifier transformers are built with phase currents up to 12 kA. It not only determines the type of secondary winding but also the expenditure for the main connections and for all the measures which have to be taken in order to keep to a minimum the supplementary losses in metal parts and in the tank caused by the strong magnetic fields. The use of non-magnetic steel at the points affected prevents the formation of hot spots due to eddy currents, a condition which could lead to premature aging of the oil or of the adjacent insulation. It should be noted that in the case of transformers for electric furnaces the secondary current is frequently much higher than is the case with rectifier transformers. The ends of the single low-voltage winding are generally run direct to terminals on the side of the transformer tank. With rectifier transformers, however, the bushings of the two low-voltage windings are located on the cover of the tank. For instance, with circuits employing interphase transformers, it is necessary to connect the interphase transformer between the two star points and then to take the neutral leads out through the tank, as is the case with the transformer shown in Fig. 4, the two star points of which each carry 12.5 kA. From this figure can also be seen the difficulties involved in arranging the leads when the secondary windings are to be provided with 50% taps. Here, this was made necessary by the requirement that the electrolytic plant be operated at 50% of the full voltage but at the same current over long periods of time when only half of the baths are in use. The windings are of the cylindrical type, each of the two low-voltage windings consisting of a single turn coil.

Primary side

The primary winding of a rectifier transformer does not differ very much from that of a normal transformer. The construction is made more complicated by tapped windings and phase-shifting windings, since these have to be so arranged that the conditions with respect to the secondary windings remain symmetrical. On the high-voltage side the windings may be reconnectable from delta to star. If the transformer is of the on-load tap changing type, it is necessary with a delta connection on the high-voltage side to arrange a tap changer in the

middle of each phase winding. Where delta-star changeover is not required it is more economical to connect the high-voltage winding in star. The on-load tap changer can then be arranged in the neutral end of the winding.

Mechanical construction

To enable them to withstand the high short circuit stresses resulting from the low impedance voltages, also where short circuits are frequent, the transformers must be provided with particularly strong frames and clamping devices. The compressive forces exerted on the windings are such as to prevent them from vibrating during short circuits.

In the design special attention has to be paid to the correct selection of the copper cross-sections and the types of winding since these factors are decisive for the stability of the winding. Displacement of the winding is prevented by artificial aging, this being achieved by drying and careful treatment.

Transformers with transductors

The development of silicon rectifiers with high inverse voltages and a high current carrying capacity has led to the introduction of a new type of rectifier transformer.

With metallic rectifiers it is not possible to control the d.c. voltage by means of a grid as is done with the mercury-arc rectifier; for this reason a magnetic control system has been developed which incorporates transductors. These are biased by direct current, the magnitude of which determines the output voltage. The iron being controlled by the variation between positive and negative saturation. The iron cross-section and thus the size of the transductors is dependent on the voltage range [2, 3].

Owing to the low secondary voltage and to the comparatively high secondary current, particularly in the case of electrolytic plants, the transductors are generally arranged on the low-voltage side. As shown in Fig. 5 they are generally of the single-conductor type and are connected direct to the ends of the low-voltage winding of the transformers. With the three-phase bridge circuit the utilization of both half waves makes necessary twice as many transductors as are required for the interphase transformer connection.

The transductors for this circuit are exclusively of the single-conductor type consisting of a copper tube over which the iron core is fitted. For reasons associated with manufacture and also to obtain better cooling, the individual cores are produced by coiling magnetically high-grade grain-oriented steel tape on a mandrel. To obviate any unduly high increase in the noise level of the transformer, the effects of magnetostriction are kept to a minimum by proper clamping.

The thickness and the diameter of the copper tube depend on the magnitude of the current, the temperature conditions and the mechanical requirements. The tube is at the same time the main support, an arrangement which makes the construction of the transductor relatively simple and facilitates assembly with the transformer.

The copper tube acts as the power winding of the transductor which in this case therefore consists of only one turn. The control windings provide the d.c. biasing and must be fitted individually to each core. These are then connected in series and brought out to terminals above the cover (see Fig. 5).

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FM 120/7000 — a Radio Relay System for 4 to 120 Telephone Channels

By Fritz Kaiser

In establishing radio relay telephone networks and individual links there is a frequent demand for a radio relay equipment that is capable of handling large groups of telephone channels but can also be used economically where there are only a few telephone channels. Its r-f range should lie as far as possible above the most commonly used ranges.

These requirements are met by the FM 120/7000 radio relay system (Fig. 1). The group of telephone channels can cover the carrier band from 6 to 552 kc. The system is adapted to the familiar carrier telephone equipment for 4 to 120 (132) telephone channels, e. g. V 4/12, VZ 12, V 60 Fu, V 120 Fu or V 120 Fu with VZ 12. In addition, a service channel allocated the frequency position 0.3 to 4 kc allows the simultaneous transmission of service messages and remote control signals.

The system operates with frequency modulation in the r-f band from 6325 to 8500 mc. This range is divided into continuously tunable subranges of a width of about 300 mc within which the pairs of r-f channels can be set in a simple manner. The 161-mc separation between the transmitting and receiving frequency represents approximately half a continuously tunable range.

The system conforms to the specifications on the West German Post and to the recommendations of the CCITT for long-range communications as referred to a telephone link 1562 ½ mi. in length. The required transmission performance is attained for a system value of 147 db (with all telephone circuits assigned), a repeater span of approx. 31 ¼ mi., a 6.5-ft parabolic reflector connected up by way of a 98.4 ft feeder, and a fading reserve of 10 db. The transmitting power here amounts to approx. 1 watt, the receiver noise figure to 12 db, the average effective frequency swing to 100 kc, and the preemphasis to 6 db.

The antennas – gooseneck waveguide radiators with a 6.5-ft (or 3.9 ft) parabolic reflector – are fed in the case of feeders up to 98.4 ft in length by way of rectangular waveguide feeders with internal dimensions of 15 mm> 34 mm, while for longer feeders circular waveguides or diverting reflectors are used on account of the lower loss.

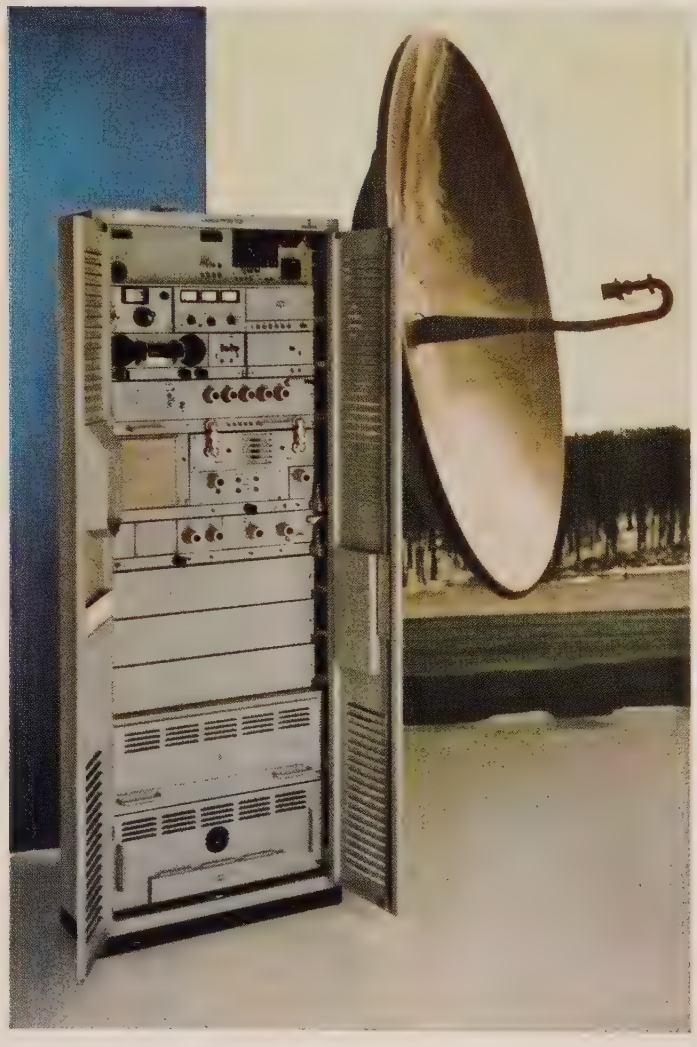


Fig. 1 Terminal of FM 120/7000 radio relay system (radio cabinet and 6.5 ft parabolic reflector)

With identical polarization of the radio beams, the operation of parallel radio paths requires that the pairs of r-f channels be spaced 14 mc apart, while for cross-polarization 7 mc is already sufficient. Given a separation of 49 mc, the same antenna can be used for up to three pairs of r-f channels (3×120 telephone circuits). The antenna terminals of the cabinets are then coupled to the common feeder by way of a ferrite circulator.

Relay stations consist of two terminal cabinets and are interconnected in the carrier frequency position. As the baseband is here available, some of the telephone channels can be readily dropped. The separating filters or hybrid sets required for dropouts can be accommodated in the cabinets. The radio relay system is also suitable for use at nonattended relay stations. Terminals are provided for remote monitoring. Full operating reliability is secured by telemetering and standby equipment with automatic changeover facilities or with diversity equipment.

The cabinets contain all the measuring equipment required for level adjustment and for the monitoring of operation; supplementary measuring equipment is therefore not required. In addition to the conventional measuring equipment, there are also a high-accuracy waveguide frequency meter and devices for measuring under r-f loop short-circuit conditions, for measuring the linearity of transmitter and receiver, and for the broadband measurement of carrier and audio levels. Breakdowns in operation automatically originate visual and audible alarm signals as well as remote control and changeover signals. Fault indications are transmitted over the service channel by a signal sender.

The overall equipment, which operates at ambient temperatures of up to 55 °C, is composed of plug-in chassis units (Fig. 2) accommodated in a 4.9 ft cabinet. In addition to the radio and measuring equipment, the cabinet is also able to accommodate a complete set of equipment for automatic changeover to a standby cabinet, space and frequency diversity equipment, and a carrier power amplifier (for feeder cable up to 13 ⅛ mi. in length) and carrier dropout equipment. A circulator for connecting several radio cabinets to one and the same antenna is also installed in the cabinet.

The system is adapted to operate on commercial a-c power supplies of 220 v ± 10% and a frequency between 47 and 63 cps. The power input is approx. 500 va.

The operating principle is, in brief (Fig. 3): the group of telephone channels incoming in the frequency position 6 to 552 kc is fed through adjustable balancing networks (for matching into the impedances of 75 or 150 ohms) to a plug-in equalizer assembly, which is composed, depending

on requirements, of cable equalizers for short lines (up to 1¼ mi.) or, in the case of long radio links, a system equalizer. The assemblies also embody an attenuator that is adjustable in 0.5 db steps in the range from 0 to 31 db. The single-stage modulation amplifier that follows combines the multichannel message band (6 to 552 kc), the service channel band (0.3 to 4 kc) and the pilot tone (304 kc) into the baseband and boosts the input signals to the level required for frequency modulation. This depends on the slope of the modulation characteristic of the transmitting klystron and is adjustable with the aid of a swing control provided at the grid end. Furthermore, a preemphasis of 6 db can be cut into the negative feedback path.

The transmitter, which is a free-running reflex klystron, converts the baseband waves into frequency-modulated signals and at the same time generates the transmitting power of approx. 1 watt. Automatic control of klystron temperature maintains the transmitting frequency of 2×10^{-4} suitably stable. For this purpose a Thernewid* thermistor with negative temperature coefficient mounted on the klystron readjusts the speed of the built-in blower by way of a magnetic amplifier so that the klystron temperature remains stable over an ambient temperature range of −5 to +55 °C. The klystron temperature thus lies 50 °C below the admissible top limit and so considerably lengthens the life of the klystron. An isolator behind the transmitter prevents any mismatch between the following component and the antenna from reacting back upon the klystron. Finally, the transmitted frequencies pass through the antenna filter and the feeder to the antenna.

A silicon diode connected to the output at the antenna end of the antenna separating filter for measuring the power output acts at the same time as a mixer diode for r-f loop measurements. For this application a built-in generator supplies an auxiliary wave whose frequency is equal to the distance between the transmitting frequency and the receiving frequency. This wave combines with the transmitting frequency, which it translates to the receiving frequency position. The translated signal is now able to pass through the receiver, where it can be evaluated for measuring purposes. A pad interposed between the filter and the antenna output is adjustable between 0 and 30 db to reduce

* Trade-mark

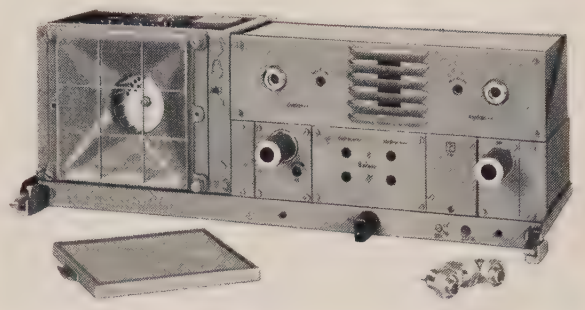


Fig. 2 Chassis unit with subassemblies: blower with automatic temperature control (left); transmit klystron and receive klystron (top right).
Modulation amplifier, automatic control for klystron voltages, equalizer and test generator (bottom left to right)

transmitting power and receiving power in the case of short-range operation; in the 30-db position the output and input signals are so attenuated that measurements can readily be performed at the cabinet without disconnecting the antenna.

The receiver is a conventional heterodyne model. The signals picked up by the antenna pass through the antenna filter to the receiving mixer, where they are translated to the i-f position of 70 mc. The tunable mixer circuit enhances the image rejection of the receiver and acts at the same time as a frequency meter for the receiving oscillator, which is a reflex klystron of the same type as the transmitting klystron. The oscillator frequency is main-

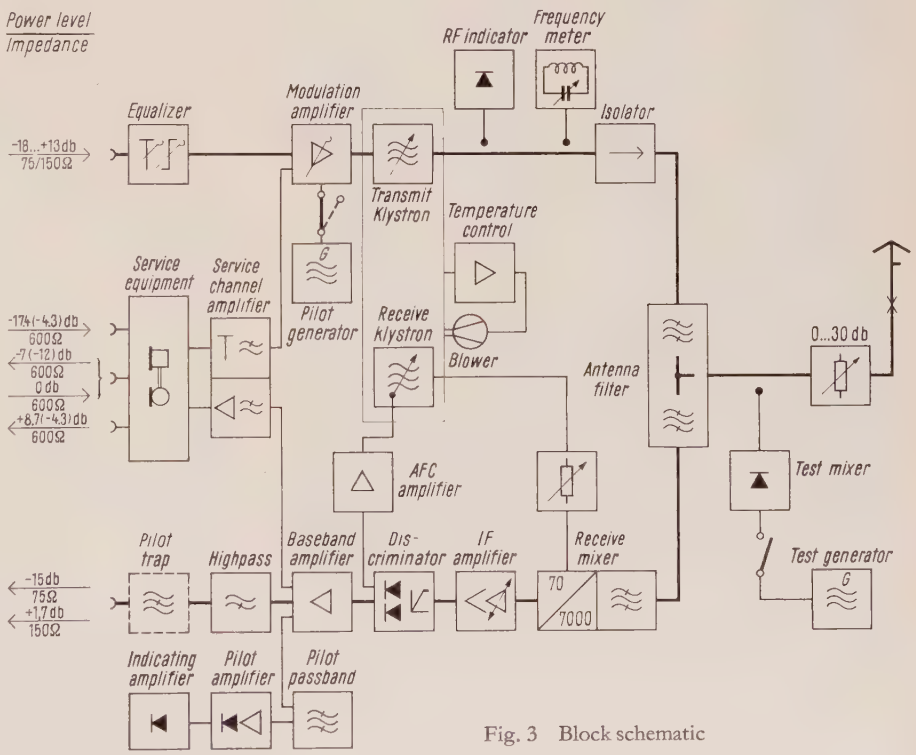


Fig. 3 Block schematic

tained stable by way of an automatic control feature controlled by the discriminator. In the event of any inadmissible frequency deviation, the signal device operates. Next, the incoming wave translated to the i-f position in the mixer is fed to the i-f amplifier, where it is selectively amplified. The five-stage amplifier equalizes the range −40 to +5 db as referred to the average attenuation of a repeater span of about 31¼ mi. The variations of the AVC voltage and of the currents of the AVC tubes as a function of receiving field strength are utilized for approximate indication of the attenuation of the repeater span and for indicating the breakdown of the receiver and the interruption of transmission; the threshold of indication is adjustable.

The amplified i-f waves are next fed through a delay equalizer to the amplitude limiter, which is followed by a discriminator that translates the frequency-modulated i-f waves into baseband signals. The following baseband amplifier boosts their level to the required output value and then separates the service channel and pilot tone from the carrier signals. In the negative feedback path of the two-stage amplifier a deemphasis network can be cut in to compensate the preemphasis frequency response of the modulation amplifier. Whereas the carrier voltages pass respectively through a 6-kc high-pass filter (for separating residual service channel signals), a plug-in pilot trap and adjustable matching networks to the carrier output, the service channel is branched off to the service equipment and the pilot tone, after passing through the pilot bandpass filter, to the pilot receiver.

The pilot device, which is composed at the transmitter end of a crystal-controlled 304-kc generator and at the receiver end of the pilot filter with pilot receiver, performs three functions. First, it monitors the radio equipment in the respective monitoring section. Second, it permits adjustment of the frequency swing without the need for additional equipment. Third, it acts as a measuring device for aligning the linearity of transmitter and receiver.

The service channel equipment is composed of all the devices required for answering and signaling, and furnishes 2-wire or 4-wire connections to detached telephone stations. The service channel is used on a party-line basis and the various stations answer to the all-stations call signal of 2280 cps.

New Siemens Long-rod Insulators

By Theodor Wittenzellner

The correct rating of the insulation is of the utmost importance for the operational reliability of transmission lines. Many types of solid-core insulators, particularly long-rod ("Langstab") insulators, and a number of experimental types still in the trial stage are evidence of the efforts being made to improve the components to meet the ever-increasing requirements.

Among the experiments carried out so far in the improvement of insulators the following may be mentioned: Further reduction of the flashovers occurring at sunrise and during fog – particularly after long dry spells – at the line-to-earth voltage in normal operation by using insulators of special shape (fog-type insulators); improvement of the load conditions at the transition from the free part to the cemented part of the shank by redesigning the shank ends and end caps; prevention of fractures inside the end cap by appreciably increasing the cross section and length of the shank ends.

Strictly speaking, the requirements of the electricity supply undertakings can be reduced to the following:

1. The electrical reliability should be as high as possible with regard to the increasing atmospheric contamination.
2. The mechanical reliability should be as high as possible with regard to the increasing transmission line capacities.

Clear and simple as the problem may seem, the solution to it is, however, difficult to find. In the technical literature there is an ever-increasing tendency to quote only the peak value of the electrical and mechanical tests for the individual products. This can lead to false conceptions when assessing the performance of insulators. The factors which are important for the achievement of peak values are not alone sufficient to ensure good quality. The real quality of products depends not only on the breaking strength or the maximum insulation strength but also on maintaining as uniformly as possible various properties (e.g. narrow range of deviation of the breaking strength values, as uniform a distribution as possible of the points of fracture when overloaded, prevention of fractures in the end caps, glazing and baking defects and porosity). In the long run, however, further development will only be profitable if not only qualitative comparisons, but rather precise values reproducible at any time can be given. This applies both for the mechanical and the electrical properties of the insulator.

The Siemens-Schuckertwerke have undertaken to develop insulators which, with a specified length and low

price, will have the highest possible insulation strength and fully utilize the specific tensile strength of the insulating body.

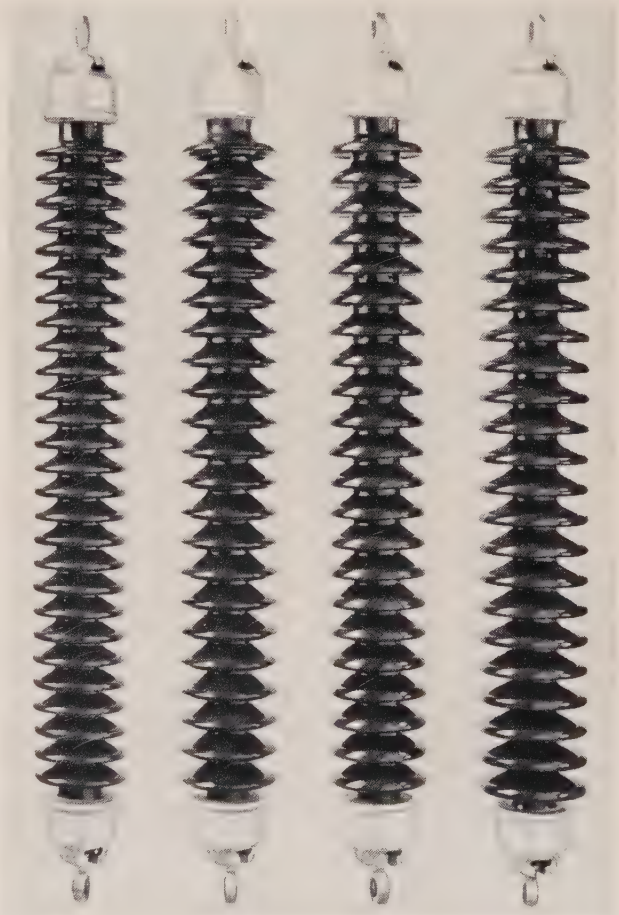
A great deal of thought has been given to the factors affecting the insulation strength and numerous experiments have been carried out in this connection. A significant part is played by the length of the insulating body or insulator string. Concerning the surface contours, one must differentiate between models with plain sheds (including sheds with small grooves on the underside) and those with petticoats. To the first group belong all conventional long-rod insulators, and to the second the fog-type insulators of foreign manufacture and the German fog-type cap-and-pin insulator (NK 3). But for one model [1], the insulation strengths of the two groups differ greatly. The majority of all other fog-type insulators fall under these main categories.

Recently it has become possible to establish differences in the insulation strengths of the various types so clearly by means of improved testing methods [2] corresponding more accurately to actual operating conditions that the insulators under test could be classified according to their insulation strengths on the basis of the results of the tests. An economical insulator could thus be developed which, on the one hand, has a high insulation strength and, on the other, can be manufactured at a fair price.

A versatile insulator must of necessity represent a compromise between various properties which do not always complement each other. Until now, the fog-type long-rod insulators of types VKNL 75/17 and VKNL 75/27 with 17 and 27 sheds respectively have given excellent service in German overhead line systems. Faults only occurred where the insulator or insulator string was of insufficient length. With the aid of the contamination-layer testing method [3] developed in the Schaltwerk of the Siemens-Schuckertwerke a series of insulators were subjected to tests. In order to keep the total creepage distance as uniform as possible, the number of sheds and the shed diameter were so varied for the same overall length that the ratio between the shed projection and the distance between the sheds remained practically constant. Since in the most unfavourable case – earth fault in a system not solidly earthed – the voltage between line and earth may exceed the line-to-line voltage, it was considered advisable, assuming a maximum permissible continuous operating voltage, to cover preferably the ranges of the line-to-earth voltage 125 kV/$\sqrt{3}$ = 72 kV and the line-to-line voltage 125 kV.

The maximum insulation strength is obtained with a long-rod insulator which has 22 sheds and a shed diameter of 175 mm ($6^7/_8$″). This dimension is regarded as the upper limit at which economical manufacture is still possible. If the shed diameter is reduced to 150 mm ($5^7/_8$″) the insulation strength will drop, but the manufacturing costs will drop even more. In Table 1, column 4, the limiting value of contamination conductance of the VKNL 75/27 long-rod insulator (conductivity of the contamination layer with which the insulator may be covered so that the test voltage of 72 kV is still the withstand voltage and no more) was taken to be 100. The limiting value of contamination conductance is a measure for the insulation strength of the insulators. In the voltage range of 72 kV, as shown in Table 1, the differences are particularly noticeable. At voltages around 125 kV, on the contrary, the insulator with petticoats (line 4) has an excellent insulation strength even in this range. It has a withstand voltage which is about 40 percent higher than that of the best plain-shed insulator (line 2). A comparison of columns 4 and 5 shows that the SVKL 75/22 long-rod insulator is the most economical for normal operation.

The investigations, which covered a space of several years, had proved that further increases in the insulation strength could actually be achieved with plain-shed insulators, but that the re-designing of the external contours necessary to do this made for uneconomical manu-



VKNL 75/27 SVKL 75/22u SVKL 75/22 SVKL 75/22s

The new Siemens-Schuckert long-rod insulators

facture. On the other hand, such good results were obtained using sheds with petticoats that these styles were taken as the basis of further investigations into the design of the insulators.

Such sheds were already subjected to tests more than ten years ago. Not enough attention was paid to the results, however, since, at the time, prime consideration was given to the wet flashover voltage of the clean insulator. It was only when investigations were made into the contamination layer problem that the superiority of the "dead-space" type (with sheds and petticoats) over the plain-shed insulators was shown. Insulators with petticoats which, owing to their construction, are only partly cleaned by rain, have a very high insulation strength (see Table 1, line 4) and are therefore particularly suitable for use in regions where, within a short space of time, contamination layers of high conductivity, which lead to flashovers, can accumulate without it being possible to clean the insulators.

The illustration shows the long-rod insulators contained in Table 1. All four models have the same overall length of 127 cm (4′2″). The shank diameter of each is 75 mm ($2\,^{15}/_{16}$″). The insulators are also available 89.5 cm ($2'11\,^{1}/_{4}$″) long. Models with a shank diameter of 85 mm ($3\,^{3}/_{8}$″) can be supplied for higher working loads.

Table 2 contains the characteristic data of the Siemens-Schuckert insulators described. In line 8 have been entered the breaking loads based on an annual average. These breaking loads, which are substantially higher than the standard values to DIN (German Industrial Standards) 48006 are, above all, the result of the good design of the shank end. Owing to the spherical surface, the load of the insulator body is evenly distributed over the entire depth of the cement. After it had been realised how far the mechanical and electrical characteristics were governed by the mineral composition of the ceramic body, the Siemens-Schuckertwerke developed in their Porzellanwerk (Porcelain Works) methods which make it possible to measure and dose the mineral constituents of the porcelain very accurately according to type and quantity. This gives mean breaking loads, which with the normal gripping cone, can only be achieved by using special constituents.

The breaking strength thus achieved has economical advantages. In present-day single-circuit lines up to 220 kV steel-cored aluminium conductors with a cross-section ratio of 340/110 sq.mm (0.527/0.171 sq.in.) are used. For bundle conductors up to 380 kV steel-cored aluminium conductors with a cross-section ratio of

	Insulator type	Overall length cm	Shed dia. mm	Limiting value of contamination layer conductance (comparative figure)	Costs (comparative figure) %
	1	2	3	4	5
1	VKNL 75/27	127	150	100	100
2	SVKL 75/22s	127	175	255	116
3	SVKL 75/22	127	150	190	95
4	SVKL 75/22u	127	155	550	108

Table 1 Comparative figures of the Siemens-Schuckert long-rod insulators (1 cm = 0.3937 in., 1 mm = 0.03937 in.)

	Characteristic data		SVKL 75/22	SVKL 75/22s	SVKL 75/22u
1	Overall length	cm	127	127	127
2	Shank diameter	mm	75	75	75
3	Shed diameter	mm	150	175	155
4	Number of sheds		22	22	22
5	Petticoats		–	–	22
6	Creepage distance	cm	249	302	295
7	Net weight	kg	28	33	30
8	Mean breaking load (annual average)	t	15	15	*
9	Limiting value of contamination layer conductance**	μS	56	74	150

* Annual mean not available as yet. Since the dimensions of all three insulators are the same in the tension zones, it is expected that the same breaking values will apply

** With all three insulators the minimum values specified by VDE 0111 and 0446 for the dry and wet flashover voltages are exceeded

Table 2 Characteristic data of the Siemens-Schuckert long-rod insulators (1 kg = 2.2 lb.; 1 t = 2,200 lb)

Rated voltage kV	Insulator or String of isulators	Overall length m	Creepage distance cm
A Normal insulation			
110	1 × SVKL 75/22[1]	1.27	249
220	2 × SVKL 75/22	2.54	498
380	3 × SVKL 75/22s[2]	3.81	906
B Insulation for severe conditions			
110	2 × SVKL 75/14[3]	1.79	320
220	2 × SVKL 75/22 + SVKL 75/14	3.44	658
380	3 × SVKL 75/22s + SVKL 75/14s[4]	4.71	1,100
C Insulation for particularly severe conditions			
110	SVKL 75/22s + SVKL 75/14s	2.17	492
110	2 × SVKL 75/14u[5]	1.79	380
220	2 × SVKL 75/22s + SVKL 75/14s	3.44	798
220	2 × SVKL 75/22u[6]	2.54	590
380	4 × SVKL 75/22s	5.08	1,208
380	3 × SVKL 75/22u	3.81	885

1 Insulator with 22 sheds, shed diameter 150 mm
2 Insulator with 22 sheds, shed diameter 175 mm
3 Insulator with 14 sheds, shed diameter 150 mm
4 Insulator with 14 sheds, shed diameter 175 mm
5 Insulator with 14 sheds and petticoats, shed diameter 155 mm
6 Insulator with 22 sheds and petticoats, shed diameter 155 mm

Table 3 Insulators for overhead lines of 110 to 380 kV (1 m = 3.28 ft; 1 cm = 0.3937 in.)

240/40 sq.mm (0.372/0.062 sq.in.) are generally used. Taking into account the standard values according to DIN 48006, the long-rod insulators with 75 mm ($2^{15}/_{16}$") shank diameter are in both cases no longer strong enough for dead-end application, neither as double or multiple chains, unless uneconomical solutions are resorted to. Long-rod insulators with a shank diameter of 85 mm ($3^{3}/_{8}$") must then be selected. An increase in the breaking load from 10 to 12 tons (metric), which is ensured by the Siemens-Schuckert insulators, would substantially simplify both erection and storage.

The new Siemens-Schuckert insulators also offer economical advantages in the insulation of overhead lines under all field conditions. Based on the insulation classification [4] specified by one electricity supply undertaking the values in Table 3 would be obtained. According to this, all requirements can be met by simply combining two or three long-rod insulators of the 110-kV and 60-kV types. In spite of the fact that the service conditions to which the insulators are subjected vary to a great extent, these can be subdivided into the following three main groups, based on conditions in Germany:

A Normal insulation
Agricultural and forestry areas, rural townships, regions with little industry

B Insulation for severe conditions
Vicinity of large industrial plants, towns, valleys with frequent mist or fog

C Insulation for particularly severe conditions
Industrial areas with high degree of pollution

In these three groups are covered more than 90 percent of all cases. For lines erected in the proximity of thermal power stations with cooling towers or along sea coasts, it is advisable to use "dead-space" fog-type insulators. Line insulation using such types is listed as an alternative in Table 3, Group *C*.

By the mechanical and electrical improvement of the Siemens-Schuckert insulators valuable components have been created for power transmission and distribution systems, affording reliable operation even under the most arduous conditions.

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New Data Storage System for Payroll Accounting

By Karl Krotendorf

Way ahead of all competition, Siemens & Halske pioneered as early as 40 years ago a system for registering and computing man hours with the aid of punched cards. After inserting a time card in the time stamp in the conventional manner, the employee had to operate a lever, thereby producing a series of round holes in the card. The position of the holes permitted the simple determination of the actual man hours worked, i. e. the time interval between clocking in and clocking out. This time was read by placing the card on a computing matrix; "inactive" punch holes, provided to prevent fraud, were covered over by the board. Electrical scanners for computing the sum of the man hours registered daily on each card over the course of the week were also under development.

That these systems failed to achieve the expected success was chiefly due to the fact that their cost-saving capabilities were not then appreciated. Punching also presented certain difficulties. As the cards had to be handled by their owners, they frequently become crumpled or soiled. As the card material was also hygroscopic, a humid atmosphere would cause it to lose shape, thus making it difficult to punch clean holes. These factors still make work time computation by means of punched cards a problem. However, technological progress, electronic computers and teleprinter equipment adapted to operate on the Siemens Selex principle today offer a new solution which will now be described.

The new method

The new method requires that each employee be issued a permanent works ID card (Fig. 1)*. This card has a section in which 12 characters can be typed in the 5-unit teleprinter code to identify the bearer as to his wage category, the department in which he works, etc. The owner of the card inserts it in a device each morning upon entering and each evening upon leaving the factory. This device scans the code characters electrically and communicates them to a processing center, where the data are punched into tape. The card is composed of two strips of plastic foil. The perforations corresponding

* Cards and scanner are supplied by Messrs. Benzing of Schwenningen am Neckar

Fig. 1 Plastic works ID card for clocking in and out. Below the photograph is the metal insert containing data in the 5-unit code

to the code characters are made by metal inserts. The latter can readily be changed without a new card having to be issued.

Time is a cardinal factor as far as the transmission facilities are concerned, because scanning must be completed within about 2.5 sec in order to prevent employees from having to queue up at the check point. To this end the five elements of each set of perforations are transmitted simultaneously. If the scanner is located sufficiently near the processing center that it would not come too expensive to run a direct line between scanner and punch, this should be done. For larger distances, the inter-

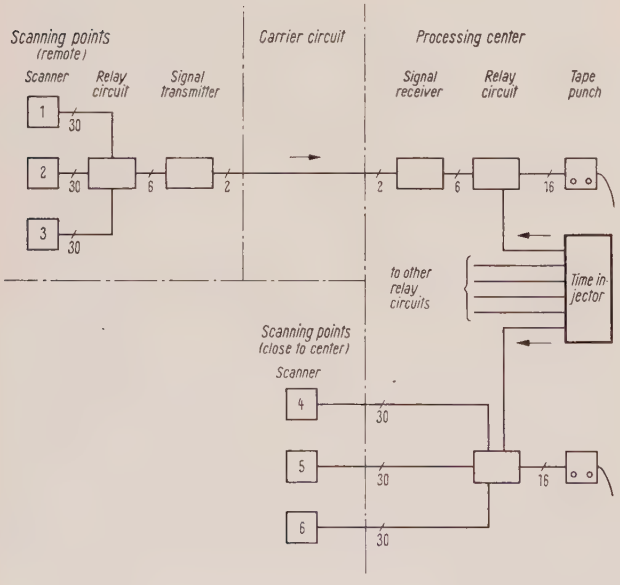


Fig. 2 Transmission of the works ID card data to a processing center

position of a transmission system operating with 5 carrier frequencies will be more economical because then only 2 lines have to be run to the processing center instead of 6.

Processing

To facilitate control of operations it is advisable to use separate scanners and separate punches for "IN" and "OUT" entries. To save time, not more than 4 IN-scanners and 4 OUT-scanners should operate into each punch. This arrangement will produce one IN-tape and one OUT-tape at the center.

At the center a time signal injector marks each tape at intervals of, say, 0.05 hrs (3 minutes), likewise using the 5-unit code, so that the individual markings are clearly related to times of arrival and departure.

The block schematic (Fig. 2) shows the layout of a system using two sets of three scanners (e. g. for IN-tapes). If carrier is used for transmission, a relay circuit located close to the scanners connects them successively to the signal transmitters. Five carrier frequencies are required to transmit the five elements of each signal and are modulated accordingly.

The carrier frequencies are transmitted simultaneously over the wire pair and segregated by bandpass filters in the signal receiver. The signal elements are then applied singly to the associated tape punch by way of intermediate relays.

The data punched into the tape represents the coded information on the works ID card plus time markers injected at certain intervals.

As the indices of each employee such as multi-digit identity number and wage factor are punched in addition to his IN and OUT times, etc., a complete record is available for payroll accounting.

Depending on the organizational setup and the payroll accounting system used, the perforations in the tapes may be reproduced in the respective index cards of each employee for accounting.

Since the data is stored in perforated tape, the system described permits the use of any type of electronic computer for data processing. Instead of being reproduced in index cards, the data can be fed classified according to employee and wage period to a memory of the Siemens 2002 digital computer. An appropriately programmed computer will then rapidly calculate, e. g. during the night before pay day, the wages of each employee as well as all deductions for taxes, insurance contributions, etc., and cause tabulating machines to reproduce the data on individual pay slips.

As it is also readily possible to connect up other processing facilities as well, an optimum solution can always be found to meet the particular requirements of any plant management.

Standard Motors

By Hans-Karl Berckmüller

In 1959 the Standards Committee for electrical apparatus formulated the German standard specifications for three-phase surface-cooled induction motors. These standards correspond to IEC Publication No. 72-1, 3rd edition, which was issued in 1959.

To the user, the standard motor affords various advantages. All the mounting dimensions of the motors are as laid down in the standards; the replacement of motors and stock keeping of spare motors are thus greatly simplified.

The new Siemens-Schuckert standard motors (Fig. 1) are totally enclosed three-phase low-voltage motors of the OR 2 type range and fully comply with the standards mentioned. Siemens-Schuckertwerke have completed the development and have started manufacture of motors with output ratings between 1.1 and 132 kW. In design and quality, the new Siemens-Schuckert standard motors are directly derived from the former type ranges of totally enclosed three-phase motors for the same range of ratings.

A distinguishing feature of the new standard motors is the advantageous utilization of volume (Fig. 2). The tendency to reduce the volume of totally enclosed motors reflects the general trend of matching the electric motor to the driven machine as closely as possible; the preference given to totally enclosed motors is also an indication of this development. A great number of low radial cooling ribs on the frame make for a compact design with good cooling characteristics, high mechanical strength and resistance to vibration.

The motors of the entire range are fitted with anti-friction bearings, the field-proven arrangement of the guide bearing at the non-drive end having been retained. This achieves uniform loading of the two bearings and a long life with accurate location of the shaft.

The spacious, rugged and tightly sealed terminal boxes are arranged in the centre of the frame throughout; this makes for an easy connection of the supply leads. The design of the motors permits assembly with brakes, zero-speed plugging switches and tacho-generators.

The rotor classification, which greatly assists selection of the right motor, has been retained. The rotor classes KL 10 to KL 16 have been co-ordinated with the individual output and speed ranges, a system which has proven its advantages over a period of many years. In the selection of the operating data of the motors – slip, efficiency and power factor – due consideration has been given to the obtaining of a well-balanced characteristic compatible with general economical requirements.

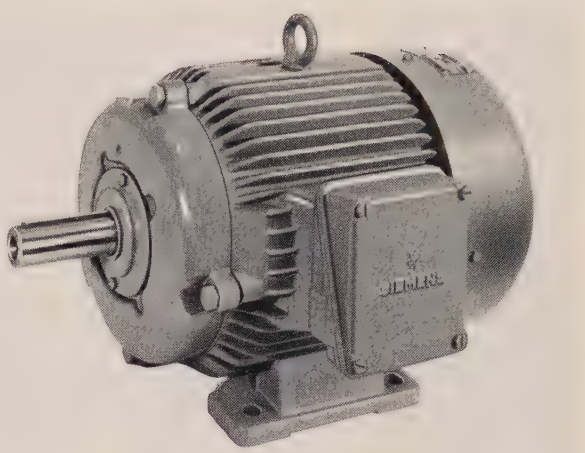


Fig. 1 Standard three-phase motor, 7.5 kW, 1,500 r.p.m.

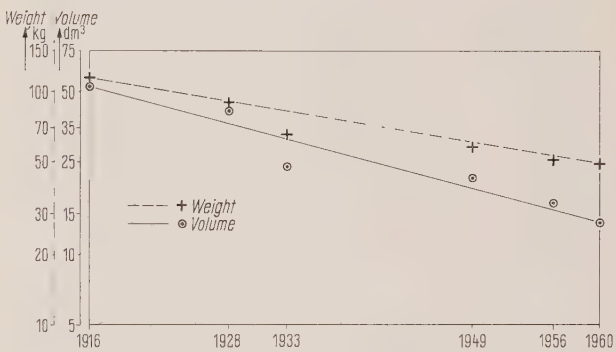


Fig. 2 Reduction in volume and weight obtained since 1916 with totally enclosed three-phase squirrel-cage motors, 4 kW, 4-pole, type OR

The winding, which is of the two-layer type as used formerly, has short robust end turns and affords a good starting performance. The varnish insulation (Class E) meets the severe requirements with respect to long life and reliability. Special care has been taken to provide for a good impregnation of the windings, a fact which is indicated by the completely filled slots and the particularly thick stoved insulating coat on the end turns. For special applications, the motors can be provided with heat-resisting Durignit* insulation.

* Trade-mark

Disk Air-Spaced R-f Cables

By Horst-Edgar Martin

Disk air-spaced coaxial r-f cables are outstanding for their low weight and low line loss. They find preferred application for the transmission of high powers and frequencies at the high end of the spectrum. The desire for good flexibility and easy installation is satisfied in large measure by the use of disk air-spaced cables. The layup of such a cable may be seen from Fig. 1: in the majority of cases the inner conductor is composed of two crimped half-tubes that are held together by the radial pressure of the insulating disks. Only in the case of models of small diameter, e. g. 5/15 (diameter above inner conductor 5 mm, diameter below outer conductor 15 mm) is a solid-drawn copper wire used instead of the half-tubes. As the insulating disks have extremely thin walls, the air component of the insulation is very great even if the disks are spaced close together. With this arrangement the losses due to leakance can be kept particularly low in comparison with other layups where more insulating material is used. The outer conductor consists in all models of two crimped copper half-tubes whose crimps are so dimensioned that, although adequate flexibility is secured, no serious increase in loss occurs despite the longer path for the current.

Fig. 1 R-f cable S & H 36/105

The outer conductor is taped with fabric that is covered in turn by a long lay of galvanized flat steel wire armoring over which is extruded a pressure-tight jacket of polyethylene of high molecular weight with an admixture of carbon black.

Mechanical advantages

The cables have particularly favorable properties with respect to withstanding mechanical stress. Despite the thinness of the metal outer conductor, the rib effect of the crimps gives the cable great resistance to pressure. As the crimped conductors absorb longitudinal expansion and compression, bending, axial stress, pressure and even temperature breathing will not cause the inner conductor to shift during operation. In the case of bending, the shape of cross section will not undergo any change. During production, installation and operation it is therefore possible to tolerate small bending radii. For example, for a cable with an outer diameter of 4.7 in. a drum core diameter of 9.8 ft is sufficient. Owing to the construction of the conductors from thin-walled half-tubes and the use of a plastic sheath, the cable is of very low weight, which is a great advantage in installation, transportation and the loading of antenna towers. Combined with the smooth surface of its sheath, the flexibility of the cable makes for simple installation with no deterioration in its high electrical and mechanical quality even in the case of complicated bends.

Constructed of crimped half-tubes, the outer conductor is self-supporting and therefore does not require inner supports designed to prevent distortion by external forces. Lightweight spacer disks may be used; they serve only for centering the inner conductor. For cables that are required to carry large powers, high thermal stability

(up to 190 °C) is secured by using polyvinylcarbazole (Luvican) spacer disks, whereas for cables designed for lower operating temperatures the spacer disks are made of polystyrene, which has a somewhat lower loss.

The polyethylene sheath protects the cables satisfactorily in a variety of ways. Owing to the extremely low diffusion constant of polyethylene, the sheath is impermeable to water and water vapor, thus permitting its use as aerial and buried cable. It further protects the steel armoring and the electrical parts from attack by corrosion. The crimps of the half-tube are at the same time protected by the polyethylene sheath from deformation in the case of bending beyond the limit of elasticity, and the stability of the cable with respect to pressure stress is improved.

Even at temperatures far below freezing point (up to − 40 °C) its flexibility does not deteriorate. Also its low thermal conductivity will be appreciated by cable-laying crews during work in intense cold.

Electrical advantages

The use of spacer disks for insulation gives rise to a periodic rise in capacitance, which presents a cutoff frequency (wavelength = twice the spacing between disks). As this cutoff frequency is always sufficiently above the highest operating frequency, the characteristic impedance of the cable is practically independent of frequency. The reproducibility of the characteristic impedance depends solely on the gage accuracy of the construction elements. The conductors consist of tape shaped into half-tubes. The tape can be cut to high accuracy in width, thus securing high precision in conductor diameter. The disks are manufactured in large production runs in an automatic injection molding unit using one and the same machine tool. Extremely narrow tolerances – especially with respect to the thickness of the spacer disk – can therefore be obtained. Elementary variations of characteristic impedance thus lie in the order of a few mils.

As a result of this uniformity of the characteristic impedance it is possible to use such cables for the broad frequency bands of the r-f spectrum. In the vhf radio broadcast and tv bands they serve for connecting transmitter and antenna (up to 800 mc), while for radio relay systems they serve as transmitting and receiving cables, and as antenna wiring cable at relay stations (up to 4200 mc). Owing to their high flexibility they are also suitable for mobile applications. This is of practical interest with types of small diameter. Trial workouts have shown that the good electrical characteristics of, say, 5/15 and 13/40 cables in no way deteriorate even after 500 rereelings.

As the standard characteristic impedance differs with the country, two line of types have been developed, one with a characteristic impedance of 60 ohms, the other with one of 50 ohms.

Fig. 2 shows the reflection coefficients attained for 5/15 and 13/40 cables in radio relay systems. These represent maximum values encountered in the various frequency bands. The different measuring lengths are classified in groups. The values stated were measured during acceptance tests at the factory and are usually improved upon following installation because the slight stretching of the cable during laying improves the homogeneity of its lay-up. The highest reflection coefficients measured between 1700 and 2700 mc (e. g. radio relay system FM 60/2000) were

$< 4\%$ for any length of 5/15 cable up to 984 ft
$< 4\%$ for any length of 13/40 cable up to 329 ft

In the radio relay band from 3600 to 4200 mc (FM 960/4000) only 5/15 cable has thus far been used. Lengths below 65.6 ft in no case exhibited reflection coefficients above 4%; with lengths between 65.6 and 329 ft the highest reflection coefficient was still below 5.5%.

The quality of a television transmission depends not on the reflection coefficients measured at individual frequencies but on local reflections within the cable, the value of which is expressed by the return loss. For cables with diameters larger than size 13/40, this lies at between 40 and 50 db.

The r-f cables described have already found widespread use both at home and abroad. 36/105 cable is used, for instance, in lengths of 1148 ft for color television in the USA. The West German Post uses 5/15 and 13/40 cables for radio relay systems, and the same types are also being used in the expansion of radio relay networks in Sweden and other countries.

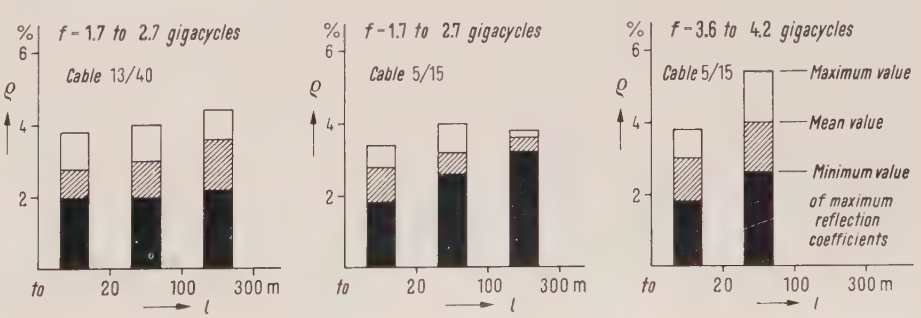


Fig. 2 Maximum reflection coefficients of cables

Siemens Transformatorenwerk

BY WILHELM STROSZECK

The Siemens-Schuckertwerke transformer works (Transformatorenwerk) which is located in the south of Nürnberg has been in existence for some fifty years. At the present time the works covers an area of about 969,000 sq.ft. and employs a staff of 3,400 of whom about 800 are women.

The manufacturing programme embraces the entire field of transformers from large power transformers with ratings of up to 300 MVA and weights of up to 240 tons down to miniature transformers rated at 1 VA and weighing 70 g. To meet the requirements of such an extensive range the works is subdivided into three groups for large, medium and small transformers.

The main part of the programme is taken up by large power transformers which are built for operating voltages of up to 400 kV. In most cases they are equipped with tap changers and are chiefly intended for application as generator transformers and system transformers. For industrial applications special transformers are built, such as rectifier and furnace transformers.

The group of medium-sized transformers consists essentially of distribution transformers with ratings from 50 to 1,600 kVA. These serve to step down the voltages of cross-country systems (up to 30 kV) to the conventional consumer voltages, e.g., 380/220 V. Also included in the medium-size range are numerous designs for special purposes.

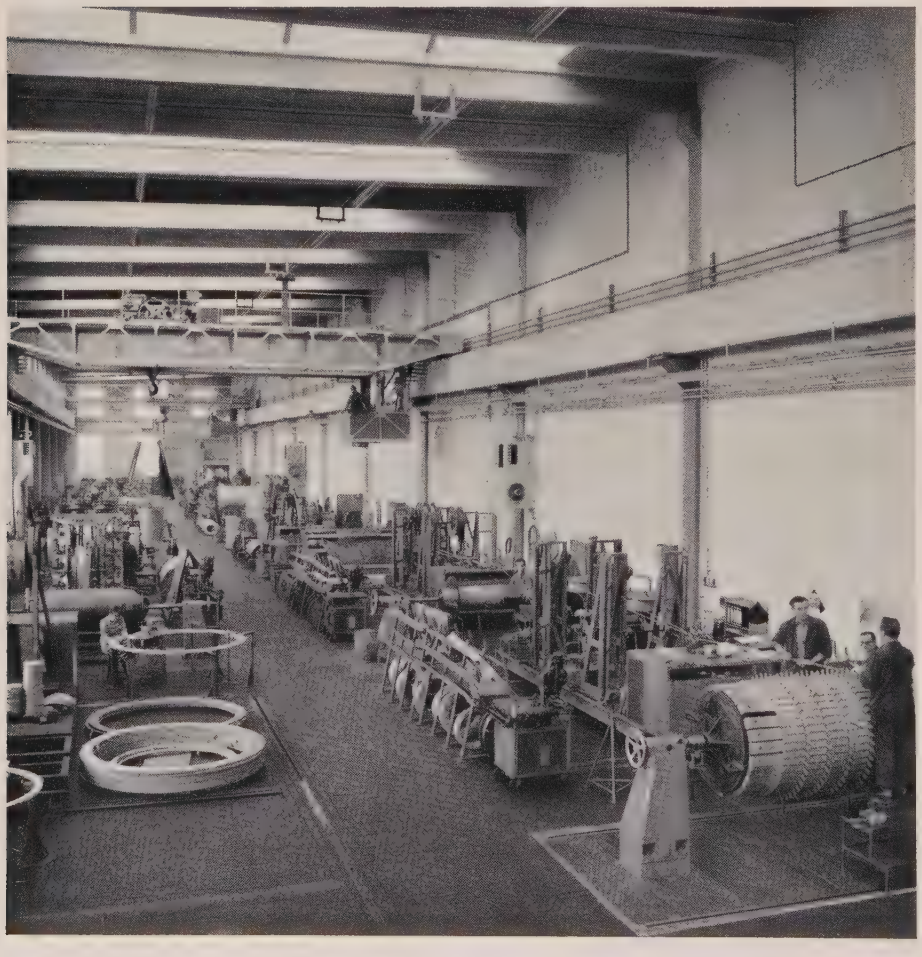


Fig. 1 Winding the coils for large transformers. Large and medium-sized transformers are generally tailor-made and are seldom quantity-produced. This applies especially to the coils since the requirements of the customer almost invariably make necessary different types of windings, even where the outputs and voltages are the same. Thus the staff employed in the winding section must be particularly highly skilled. Their experience and the care which they take are decisive for the reliability of the windings and hence for the properties of every transformer

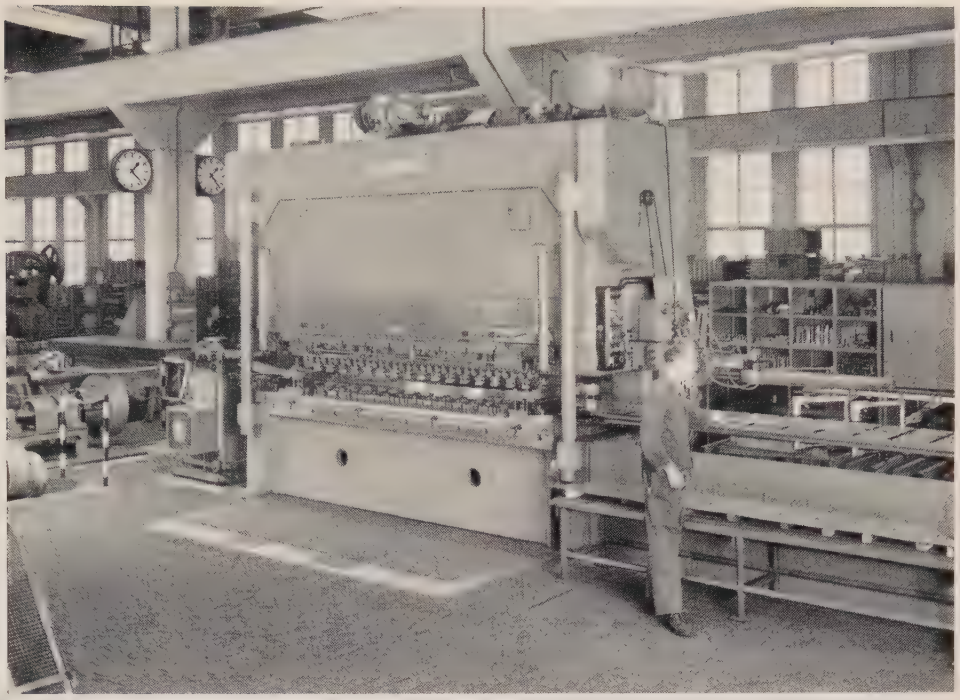


Fig. 2 Highly alloyed sheet steel is an important material for transformers. Shears with rotating blades cut the cold-rolled grain-oriented sheet, which is supplied in rolls, into strips of the required width. These are then processed further in the stamping section

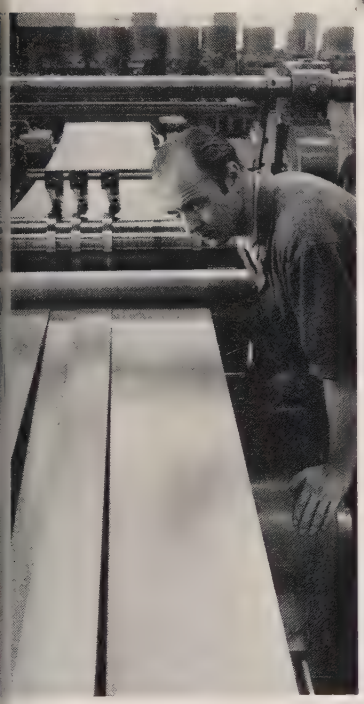


Fig. 3 Stamping machines for the core laminations of large transformers. The strips cut on the rotary shears are fed from the roll to the large stamping machine where they are cut to the right length and stamped in one operation. Stacking of the laminations is simplified by placing pins in the holes

Fig. 4 Stacking the iron core of a large transformer with the annealed sheets. Special care is necessary here to keep the magnetizing current and iron losses to a minimum

Fig. 5 Before being fitted into the tank the core and coil assembly is dried in a vacuum plant. Proper drying is essential to the operational reliability of the transformer

Fig. 6 60-MVA, 110-kV three-phase furnace transformer with separate regulating transformer for adjusting the secondary voltage on-load. This has a secondary current of 120,000 A and is one of the largest furnace transformers manufactured. It serves to supply power to carbide furnaces in the chemical industry

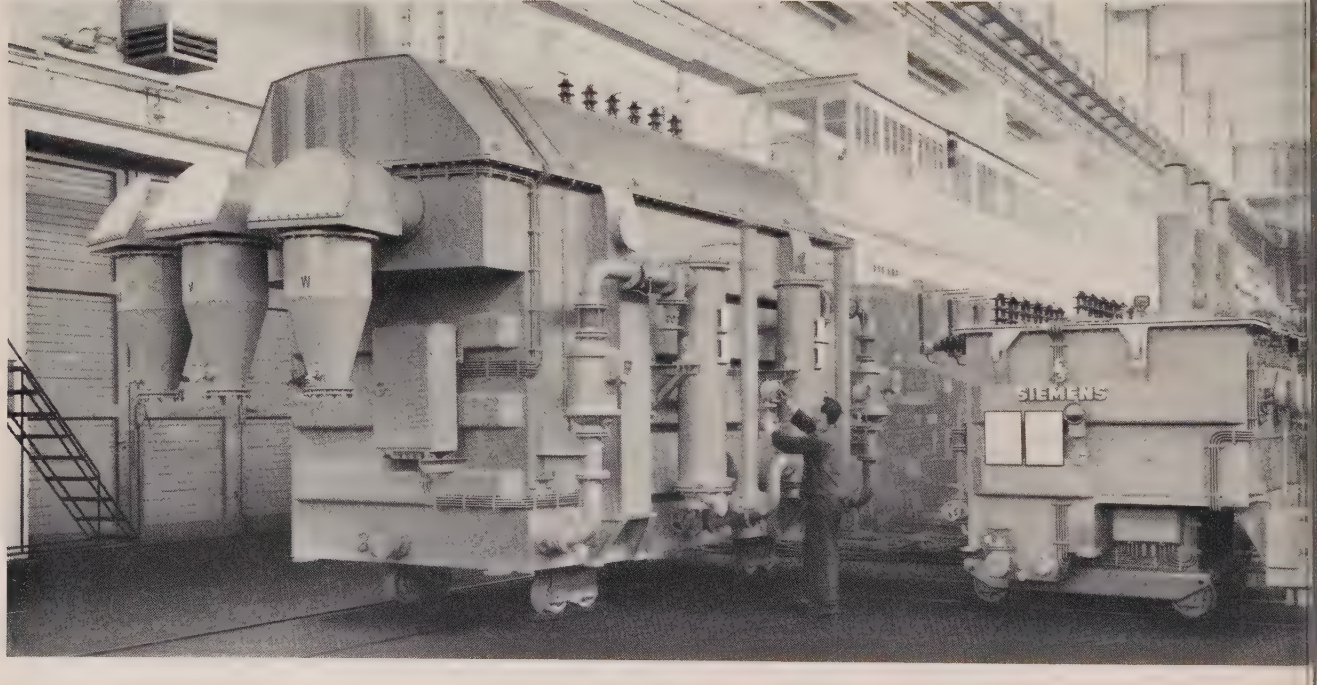


Fig. 7 220-MVA, 380/220-kV auto-transformer with tap changer on the 220-kV side shown in the testing station. With two other units this transformer forms a three-phase bank having a rating of 660 MVA. Transformers of this type were installed in 1957 for the first 380-kVtransmission system in Germany which connects the Ruhr District with south-western Germany

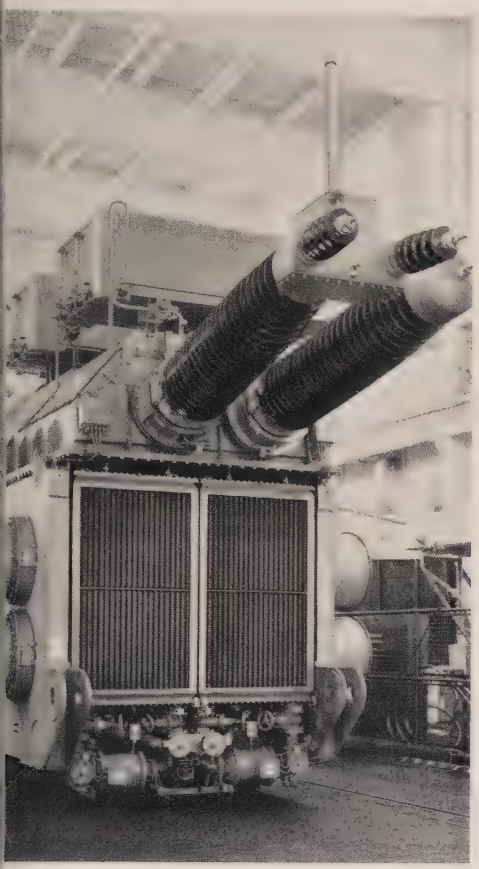


Fig. 8 Assembly of small transformers. The various parts are fitted together by skilled female staff

Small and miniature transformers are used for a variety of applications, for instance, in switching and control stations, as accessories for modern rectifier plants and as transductors. This part of the manufacturing programme is steadily increasing in importance with increasing automation.

Since transformers have a very important function, stringent requirements are made with regard to their operational reliability. To check and ensure this reliability is the task of the mechanical and electrical testing stations which at all times are kept right up to date. An outdoor extra-high-voltage testing station equipped with a surge generator for 3.6 million volts not only serves routine test purposes but also research in the entire field of extra-high-voltage engineering.

The properties of the materials used are also checked constantly in the chemical and physical laboratories. At the same time a staff of scientists is engaged on the further development of materials and manufacturing methods.

The transformer works owes much of its success to modern technical equipment and in particular to its highly skilled and efficient staff whose work is backed by decades of experience in the manufacture of transformers.

NEW EQUIPMENT

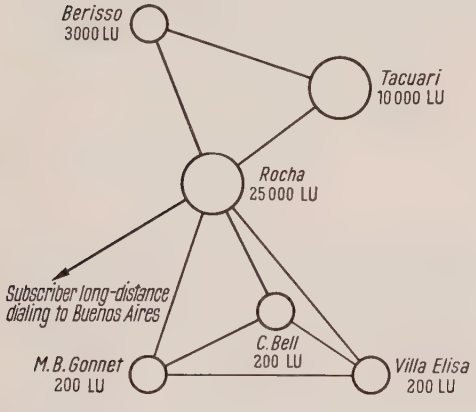
Argentina Uses Home EMD Production for Newest Dial Offices

BY GERHARD ZIMMERMANN

The inauguration of the group of La Plata dial offices with 20,600 subscriber line units was reported in 1958[1]. Simultaneously, subscriber long-distance dialing with time pulse metering was introduced in South America for the first time. This service links the group of La Plata dial offices with Buenos Aires over 100 inter-office trunks. The automatization of the Argentine telephone network with EMD switching equipment has proceeded in the interim according to schedule.

By the end of 1958 the group of Bahia Blanca dial offices with 15,800 and the Berisso dial office in the La Plata area with 3,000 subscriber line units were placed in service, followed in 1959 by Tacuari city dial office with 10,000 subscriber line units and the expansion of the Rocha city dial office by 5,000 subscriber line units (see illustration). Thus a total of 54,400 EMD line units are now in service in these two groups of offices.

All calls from the suburban dial offices to the respective city offices are established by way of discriminators. When a subscriber on a suburban office removes his handset, the respective connection is extended over the subscriber line circuit, linefinder and discriminator to the 1st/2nd group selectors of the city office (main route). For calls within the local suburban office area the already preset discriminator is switched to an intra-office route as soon as the first digit is dialed. It has been determined that about 70% of all calls flow over the main route.



Plan of the group of La Plata dial offices presently equipped with 38,600 subscriber line units

Whereas all the office equipment required for the first two stages of development was supplied by the German factories of the Siemens Telephone Division, much of the equipment installed in the dial offices placed in service in 1959 came from Argentine factories. After starting with the production of desk telephones and relay shelves, the two Siemens factories in Buenos Aires – in the suburb of Carapachay and on Ruta 8 – have now taken up the production of all the requisite switching equipment as well. Special attention is also being devoted to training skilled Argentine personnel.

The planned objective of the agreement concluded with the Argentine telephone administration (ENTel) is to gear Argentina's home production of EMD switching equipment to meet all future demands.

1 Kirn, K.: EMD Dial Office in Argentina. Siemens Review XXV (1958) pp. 226 to 229

EMD Dial Offices in Indonesia

BY HERBERT SCHNEIDERS

In Djakarta, capital of Indonesia, the existing manual telephone offices with a total of 5,600 subscriber lines became unable to cope with the steady growth of telephone traffic. Thus the Indonesian PTT decided on the initial expansion and automatization of the local Djakarta network (Fig. 1) to 21,000 telephone installations. The dial offices are to be equipped with EMD switches and are scheduled to be completed for the most part in time for the Asian Games in 1962.

The two first EMD dial offices in Djakarta were placed in service on April 21, 1960 (Fig. 2). They are located in the Kota district

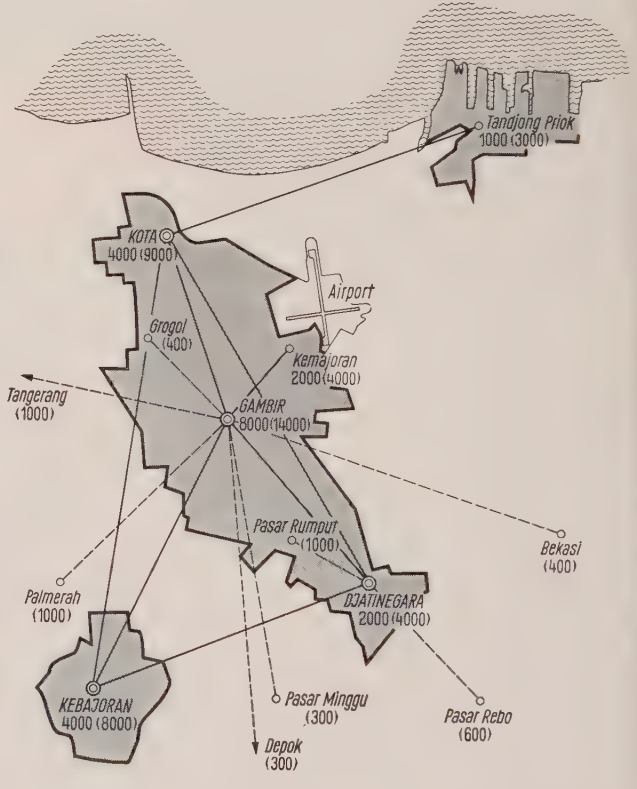


Fig. 1 Plan of local network of Greater Djakarta, initially equipped for 21,000 telephones. The figures in brackets refer to future expansion

Fig. 2 Minister Dr Leimena inaugurates the new dial offices

Fig. 3 Minister Dr Leimena, Director-General Raden Samdjun and Major-General Djatikusumo during the inauguration ceremony in Djakarta

and in the Tandjong Priok dock district (see Fig. 1). The inauguration ceremony was attended by H. E. Dr Johannes Leimena, Minister of Commerce, Transport and Communications, H. E. Major-General Djatikusumo, Vice-Minister of Overland Transportation and Communications, as well as other high government personalities (Fig. 3). H. E. Raden Samdjun, Director-General of the Indonesian PTT, stated in his address that telephone traffic in Indonesia had trebled in recent years and that to keep pace with its future growth the local network of Greater Djakarta will be expanded over the course of time to 47,000 subscriber line units (see Fig. 1).

The progressive automatization of the local network demands that the traffic between the EMD dial offices and the manual offices that still exist should be handled smoothly. Provision has been made for semiautomatic inter-office traffic as an interim solution. On dialing a certain prefix, a subscriber on an EMD dial office obtains the operator of the local manual telephone office, who then extends the connection to the wanted subscriber. Conversely, a subscriber on a manual telephone office obtains a subscriber on an EMD dial office through the operator, who dials the wanted number for him.

The first EMD dial office of the Indonesian PTT was placed in service in Malang in August 1959. It has 4,000 subscriber line units. The local network of Surabaja is at present being automatized along with that of Djakarta. As a first step, an EMD dial office with 2,000 subscriber line units is being built in the Darmo district.

The overall plan of the Indonesian PTT envisages the automatization of the principal telephone offices throughout the country within the next ten years. In this connection the Siemens & Halske AG has been awarded an order for the supply of two EMD dial offices with 1,600 and 1,000 subscriber line units respectively for Denpasar and Singaradja on the island of Bali.

In the EMD dial offices installed in Indonesia, use is made, as in the dial service network of the West German Post, of linefinders or 1st and 2nd linefinders in the preselection stage. In the local network of Djakarta the offices are to be equipped – in view of the heavy inter-office traffic – with 200-pt 1st group selectors with 20 outlets per decade instead of 100-pt 1st group selectors. This makes it possible to economize on inter-office trunks in high-usage trunkgroups. Local/toll line connectors are used in all dial offices, so enabling the operators to enter existing connections in order to offer long-distance calls to wanted subscribers.

The EMD dial offices are being equipped by Indonesian fitters under German supervision. Officials of the Indonesian PTT are undergoing training in Germany in the maintenance of the new equipment.

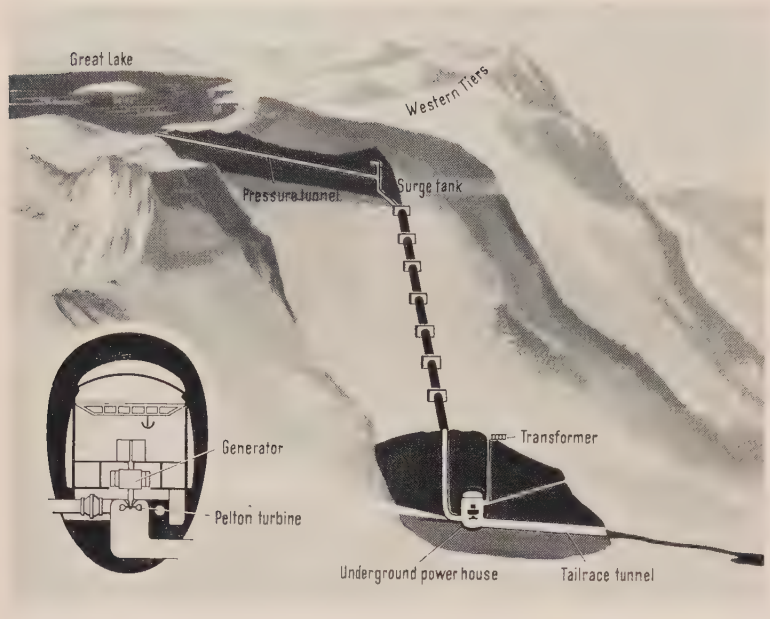
MISCELLANEOUS

A Large New Hydroelectric Power Station in Tasmania

By Herbert Galleth

In Tasmania, an island off the south coast of Australia, a large-scale power supply scheme has been prepared which makes provision for the erection of eleven hydroelectric power stations with a total installed capacity of about 1,100 MVA. A large part of this electrical power is intended for the supply of block consumers such as the aluminium, chemical and paper industry and also the railways. The largest of the eleven power stations will be the Poatina underground station with an output of 375 MVA. An order for the five 62.5-MVA, 600-r.p.m. generators for the first stage of construction has been placed with Siemens-Schuckertwerke.

Situated on a plateau 3,380 ft. above sea level is the largest lake in Tasmania, the Great Lake, which has a storage capacity of approximately 67 thousand million cubic feet. In the north and in the east the lake is bordered by the Great Western Tiers which rise to a height of 4,200 ft. From the long ridge of the Tiers the terrain



Location of the Poatina hydroelectric power station

slopes steeply down to about 525 ft. The topographical conditions lend themselves ideally to the exploitation of the water power potential, and it is quite easy to appreciate the reasons which induced the Hydro Electric Commission of Tasmania to erect its largest power station here.

Fig. 1 shows the position of the lake, the penstock and the Poatina underground power house. The water from the Great Lake is passed through the Western Tiers by a tunnel four miles long. At the end of this the rock is tunnelled out to accommodate the surge tank. From there the water is conveyed through a 10 ft. diameter penstock arranged above ground to a point over the underground power house, and then through a vertical shaft to the underground distributor. The mean head is 2,790 ft. The power house is located 525 ft. below ground level, is 328 ft. long, 65 ft. wide and 98 ft. high. It is capable of accommodating six generating units. Access to the power station is provided by a lift in a vertical shaft and also a sloping tunnel road from the surface. Having passed through the turbines, the water is discharged into the River Palmer through a free-flowing tunnel.

The power from the generators is passed through conductor bars in the lift shaft to the 16/220-kV transformers installed outdoors. From a switching station located some four miles away the power is then fed into the general power supply system.

The five 62.5-MVA generators are of the W 2 type of construction, i. e., the scope of supply includes a combined thrust and guide bearing above the rotor and the shaft with the coupling flange. The rotor is of the laminated-rim type, the yoke ring which consists of a large number of sheet-steel segments and clamping bolts being shrunk direct onto the shaft. The ten poles are securely fitted to the laminated rim by duplex T-head joints. Since the generators have a rated voltage of 16 kV, the stator winding has been provided with MICALASTIC* insulation. In addition to affording electrical advantages, this method of insulation reduces the overhang of the end turns, a feature particularly prominent at this high voltage and also desirable in view of the special endeavours made to keep the dimensions of generators in underground power stations to a minimum. The speed of the generators is 600 r.p.m. At the required output and a runaway speed of 1,020 r.p.m. the rotors are subjected to very high mechanical stresses, a point which had to be taken into account in the design of the generators. Owing to the limited lifting capacity of the cranes in the Tasmanian ports, the generators must be transported in sections with a maximum weight of 75 tons.

This is the first large order for waterwheel generators to be received by Siemens-Schuckertwerke from the Commonwealth of Australia. The scope of supply also includes the magnetic-amplifier voltage regulators, the machine boards and the unit auxiliaries.

* Trade-mark

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SIEMENS

U.D.C. 621.395.22

HELMUTH GALLO

Typical Features and Applications of Modern Pushbutton PBX's

4½ pages, 9 figures, bibliography

Siemens Review XXVIII (1961) pp. 69 to 73

Pushbutton PBX's offer small businesses all the modern telephone facilities hitherto available only to large enterprises.
REIHA Pushbutton PBX's are adapted for one outside trunk and from two to six extensions, REIPOS PBX's for two outside trunks and from two to eleven extensions.

SIEMENS

U.D.C. 621.316.37-523.8

ERNST WEILAND

Mimic Diagram Control — A New Control System for Switching Stations

4 pages, 4 figures, bibliography

Siemens Review XXVIII (1961) pp. 73 to 77

Employing the principle of the SIMATIC System and with the aid of the type of consoles used for track diagram controls, a new control system has been developed for switching stations. This control system, which is mainly contactless, makes it possible to incorporate extensive interlocking and supervisory arrangements. The building-block system permits simple construction and makes possible extensions and modifications. A detailed description is given of the construction and mode of operation of this control system.

SIEMENS

U.D.C. 621.396.73-213.44

GERHARD DROPMANN AND WALTER PINKERNELLE

Walkie-Talkie for Fiery Mines and Industrial Plants Exposed to Explosion Hazards

3½ pages, 1 figure

Siemens Review XXVIII (1961) pp. 77 to 80

In underground mines and industrial plants that are exposed to explosion hazards there is a frequent requirement for temporary communications links to be set up. Walkie-talkies are here ideally suitable. To satisfy the special requirements of such applications, Siemens & Halske have brought out a new version of their time-proven vhf walkie-talkie model that conforms both to VDE regulations and to the special regulations of the mining authorities. It meets, for example, all the specifications for gases and vapors of explosion class 3, and is completely watertight. A discussion of the peculiarities of wave propagation in underground mines is followed by a description of the constructional layout, operating principle and potential applications of the new equipment.

SIEMENS

U.D.C. 621.314.2

HELMUT FEYERTAG

Large Rectifier Transformers

4½ pages, 5 figures, bibliography

Siemens Review XXVIII (1961) pp. 81 to 85

The requirements which a rectifier transformer has to meet make it essential that its design be quite different from that of a normal distribution transformer.
The design of the secondary winding is influenced by high currents and low voltages. Particularly decisive factors in the design of rectifier transformers are wide control ranges, phase displacement on the secondary side and the installation of transductor reactors. In the article special attention is paid to transformers for mechanical or silicon rectifier plants with very high outputs.

SIEMENS

U.D.C. 621.396.4

FRITZ KAISER

FM 120/7000 — a Radio Relay System for 4 to 120 Telephone Channels

3 pages, 3 figures

Siemens Review XXVIII (1961) pp. 85 to 88

In establishing radio relay telephone networks and individual links, there is a frequent requirement for a radio relay system that permits the formation of large groups of telephone channels but can also be used economically for the operation of small numbers of telephone channels as well. A radio relay system for 4 to 120 telephone channels that meets this requirement is described. The equipment is accommodated in a cabinet. Its r-f range of 6,325 to 8,500 mc lies above those that have already been largely allocated. In addition to the radio equipment, the cabinet accommodates equipment for operational measurements; if required, equipment for dropping carrier groups and equipment for standby or diversity operation can be added.

SIEMENS

U.D.C. 621.315.622.3

THEODOR WITTENZELLNER

New Siemens Long-rod Insulators

3 pages, 1 figure, 3 tables, bibliography

Siemens Review XXVIII (1961) pp. 88 to 91

The design of the pin of the new long-rod ("Langstab") insulators permits optimum utilization of the porcelain strength. With the aid of the contamination-layer testing method, various types of long-rod insulators have been subjected to investigation to determine their insulation resistance. According to the results obtained, the most economical types are smooth shed insulators with 22 sheds (diameter 6.9 and 5.9 in) and the long-rod insulators with subsheds (diameter 6.1 in). These insulators provide effective and economical insulation for all high-voltage lines.

SIEMENS

U.D.C. 621.394.9:681.174

KARL KROTENDORF

New Data Storage System for Payroll Accounting

1⅓ pages, 2 figures

Siemens Review XXVIII (1961) pp. 91 and 92

In large organizations, payroll accounting can be appreciably simplified through adoption of the new method of checking working time here described. The method is based on the use of permanent cards with a series of individual markings in the 5-unit telegraph code. With the aid of transmitting equipment of a type widely used in telegraphy such data can be stored together with time data in a processing center and fed to a tape-controlled card punch or an electronic computer for payroll accounting.

SIEMENS

U.D.C. 621.313.333

HANS-KARL BERCKMÜLLER

Standard Motors

1 page, 2 figures

Siemens Review XXVIII (1961) p. 93

German Industrial Standards (DIN) include specifications for the most important mounting dimensions of electrical machines, and, for totally-enclosed surface-cooled three-phase induction motors, co-ordinate the outputs with the sizes. The new Siemens low-voltage squirrel-cage motors of the type range OR 2 are a further development of the older totally-enclosed three-phase induction motors. The fact that the new motors comply with the latest German and International Standards facilitates their use for a wide range of applications.

For cutting out and pasting on index cards

SIEMENS

U.D.C. 621.315.212

HORST-EDGAR MARTIN

Disk Air-Spaced R-f Cables

2 pages, 2 figures

Siemens Review XXVIII (1961) pp. 94 and 95

The makeup of disk-insulated r-f cables manufactured by Siemens & Halske is described. Conductors designed as beaded semi-tubes and the use of polyethylene sheathing have proved particularly advantageous from the mechanical aspect. As close production tolerances and the very favorable electrical properties of the materials used for the disk-insulation permit both high uniformity in characteristic impedance and high transmitted powers, all types can be used for broad frequency bands.

SIEMENS

U.D.C. 621.395.72(82)

GERHARD ZIMMERMANN

Argentina Uses Home EMD Production for Newest Dial Offices

½ page, 1 figure

Siemens Review XXVIII (1961) p. 100

Report on progressive expansion of Argentine telephone network with EMD equipment. 54,400 EMD terminals of the 300,000 ordered have now been placed in service in the two extended-area networks of La Plata and Bahia Blanca. Further plans foresee the future production of all EMD equipment in Argentina.

SIEMENS

U.D.C. 621.395.72(91)

HERBERT SCHNEIDERS

EMD Dial Offices in Indonesia

1 page, 3 figures

Siemens Review XXVIII (1961) pp. 100 and 101

In line with the expansion and automatization of the Indonesian telephone network, dial offices initially equipped for 21 000 subscriber line units are to be established in Djakarta. Two dial offices for 4000 and 1000 subscriber line units respectively have already been placed in service.

The grouping of switches and the handling of traffic between the dial offices and the old manual offices are described.

EMD dial offices are also being established in other parts of Indonesia and some are already in operation.

SIEMENS

U.D.C. 621.311.21(946)

HERBERT GALLETH

A Large New Hydroelectric Power Station in Tasmania

1 page, 1 figure

Siemens Review XXVIII (1961) pp. 101 and 102

The large new power station Poatina built for the Hydro Electric Commission of Tasmania is fed with water from the Great Lake (storage capacity about 67 thousand million cu.ft.). The mean head is 2,709 ft.

The order for the five 62.5-MVA generators for the first stage of construction has been placed with Siemens-Schuckertwerke. Ultimately the power station will have six generating units.

SIEMENS